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(54) Automatically processing incoming calls

(57) Improving processing of a telephone call for one of a plurality of individuals accessible through a plurality of phone extension stations or outside telephone number stations by a system that automatically answers a phone call, receives information identifying the individual being called, refers to a memory to obtain call handling information identifying at least one designated station at which the individual being called is likely to be accessible, and causes the incoming call to be connected to a designated station.

FIG 1

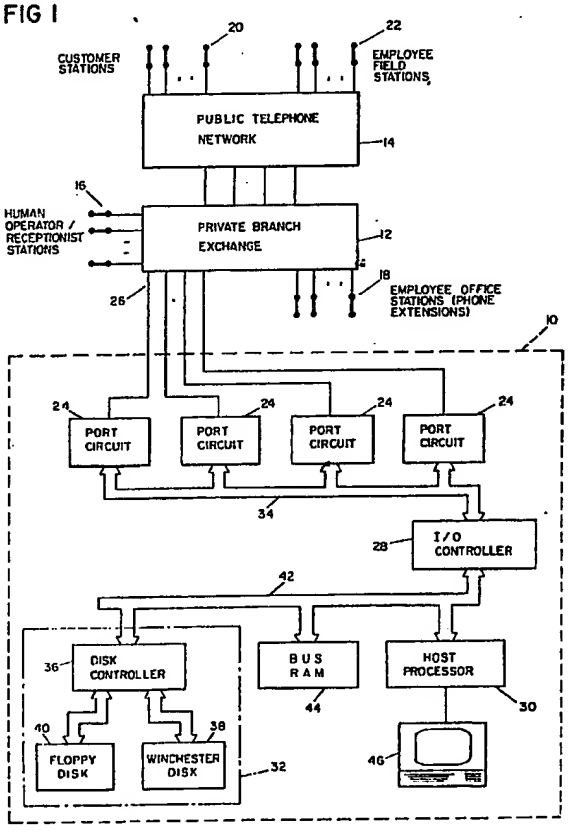

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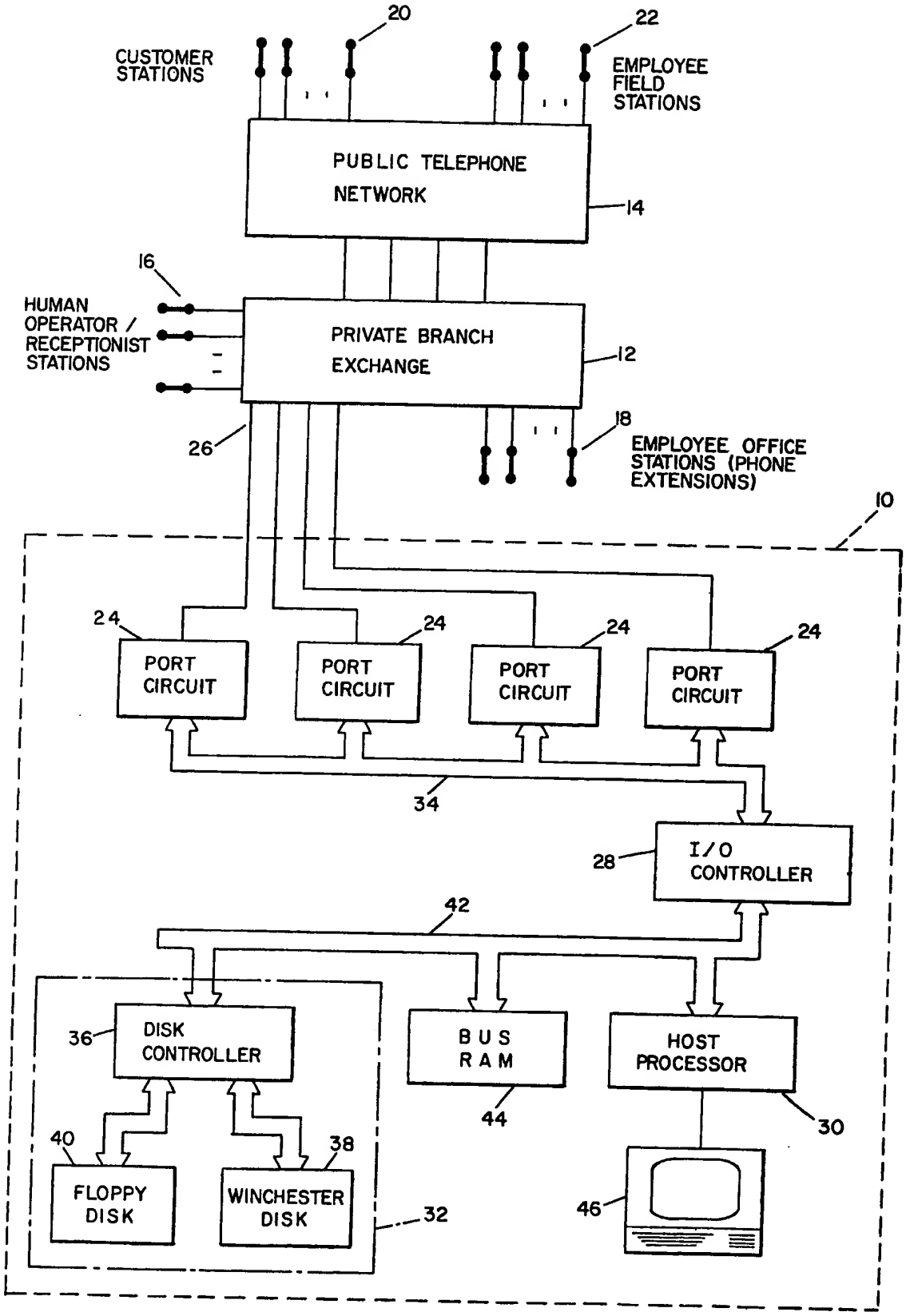
FIG 1



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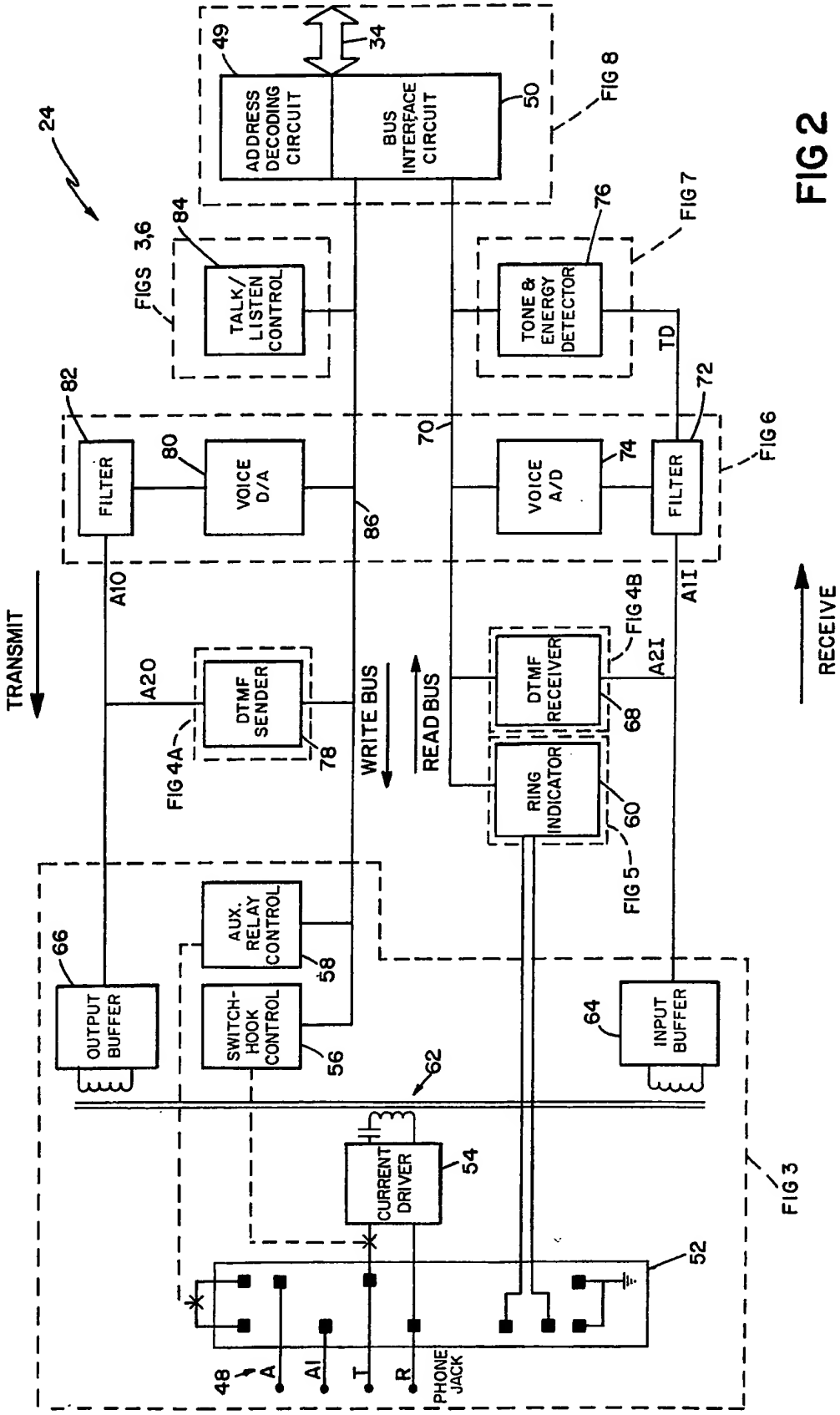

FIG 2

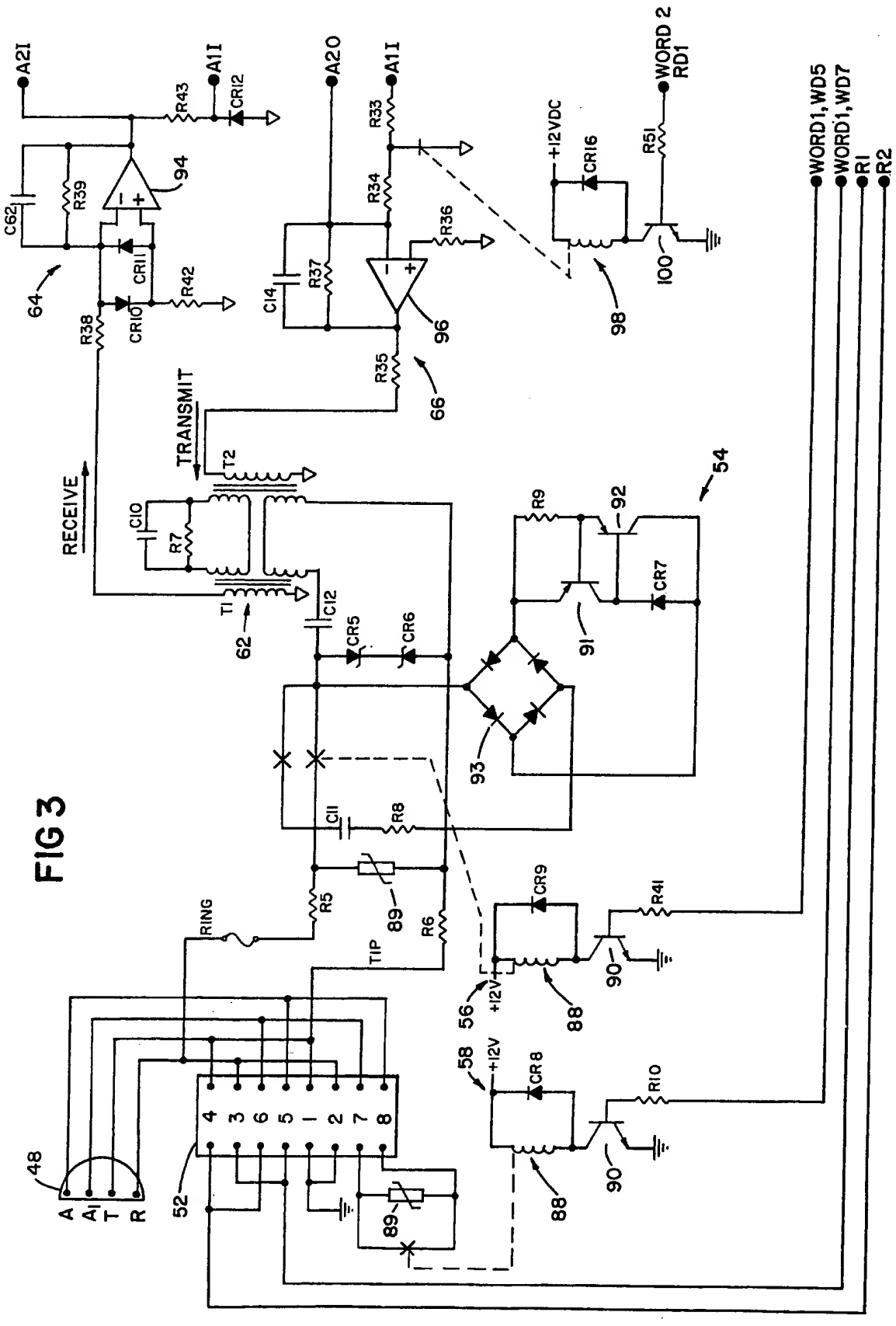
A2I
A1I
R43
CR12
C62
R39
94
CR11
64
R42
CR10
R38
A2O
A1I
R33
R34
R36
C14
R37
96
R35
66
+12VDC
CR16
R51
WORD 2
RD1
100
98
WORD1, WD5
WORD1, WD7
R1
R2
TRANSMIT
T2
RECEIVE
C10
R7
T1
62
C12
CR5
CR6
54
R9
92
CR7
91
93
C11
R8
R5
89
R6
RING
TIP
CR9
R41
90
56
+12V
88
58
+12V
CR8
R10
90
88
4 3 6 5 1 2 7 8
48
A
A1
T
R
52
89

FIG 3

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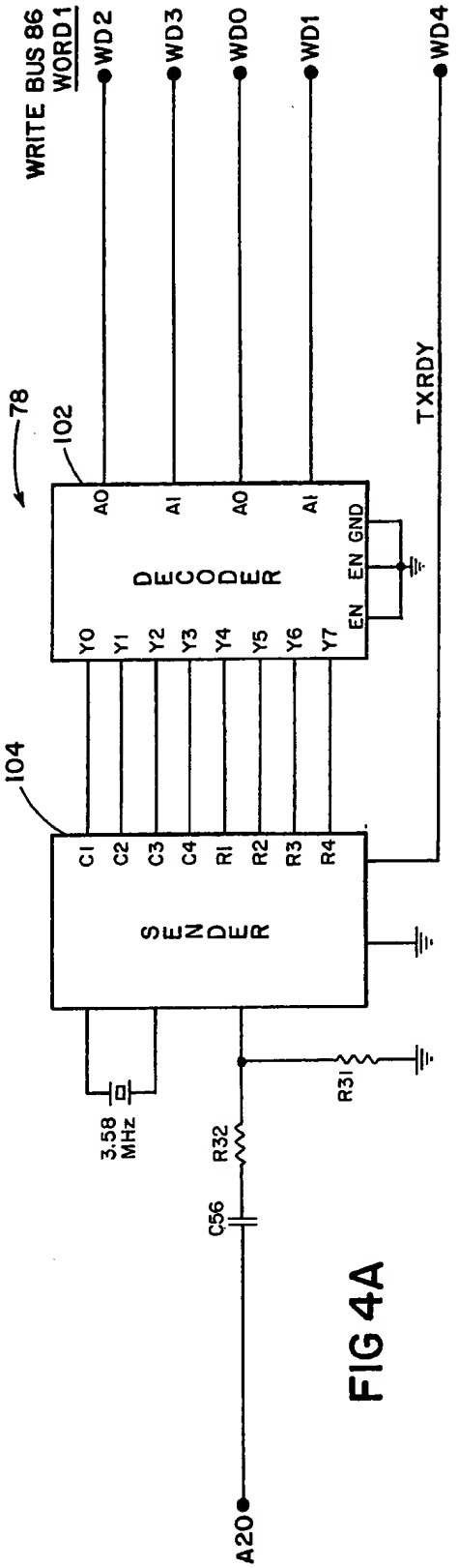

FIG 4A

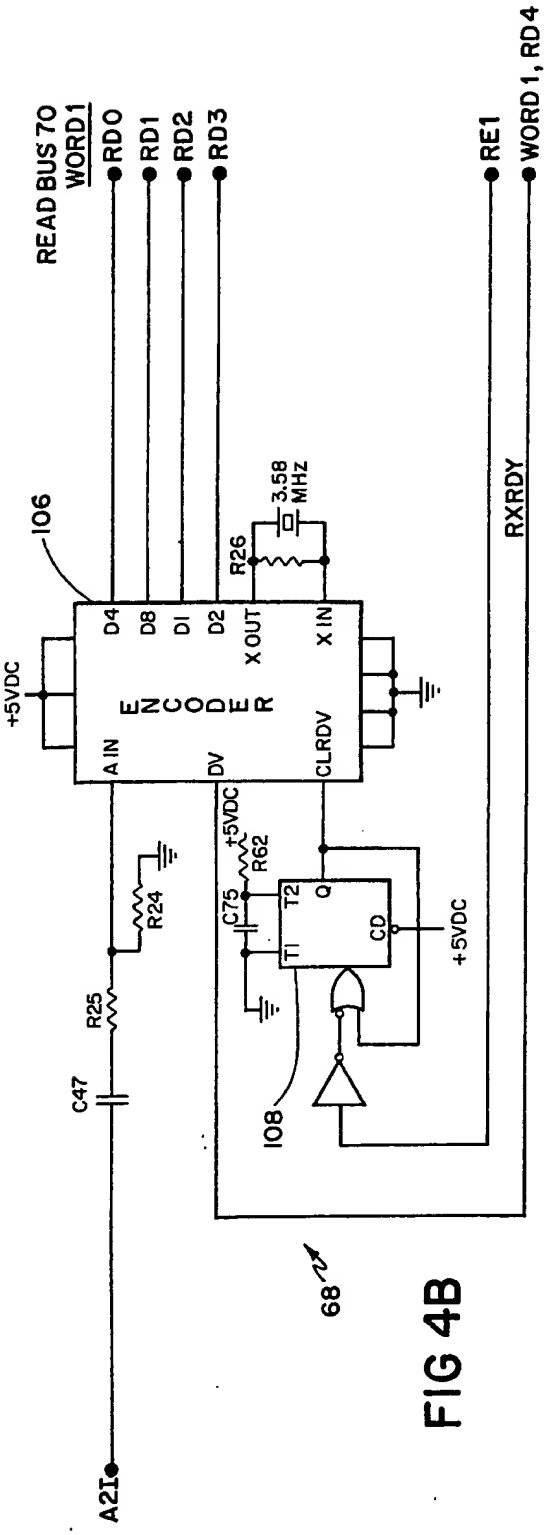

FIG 4B

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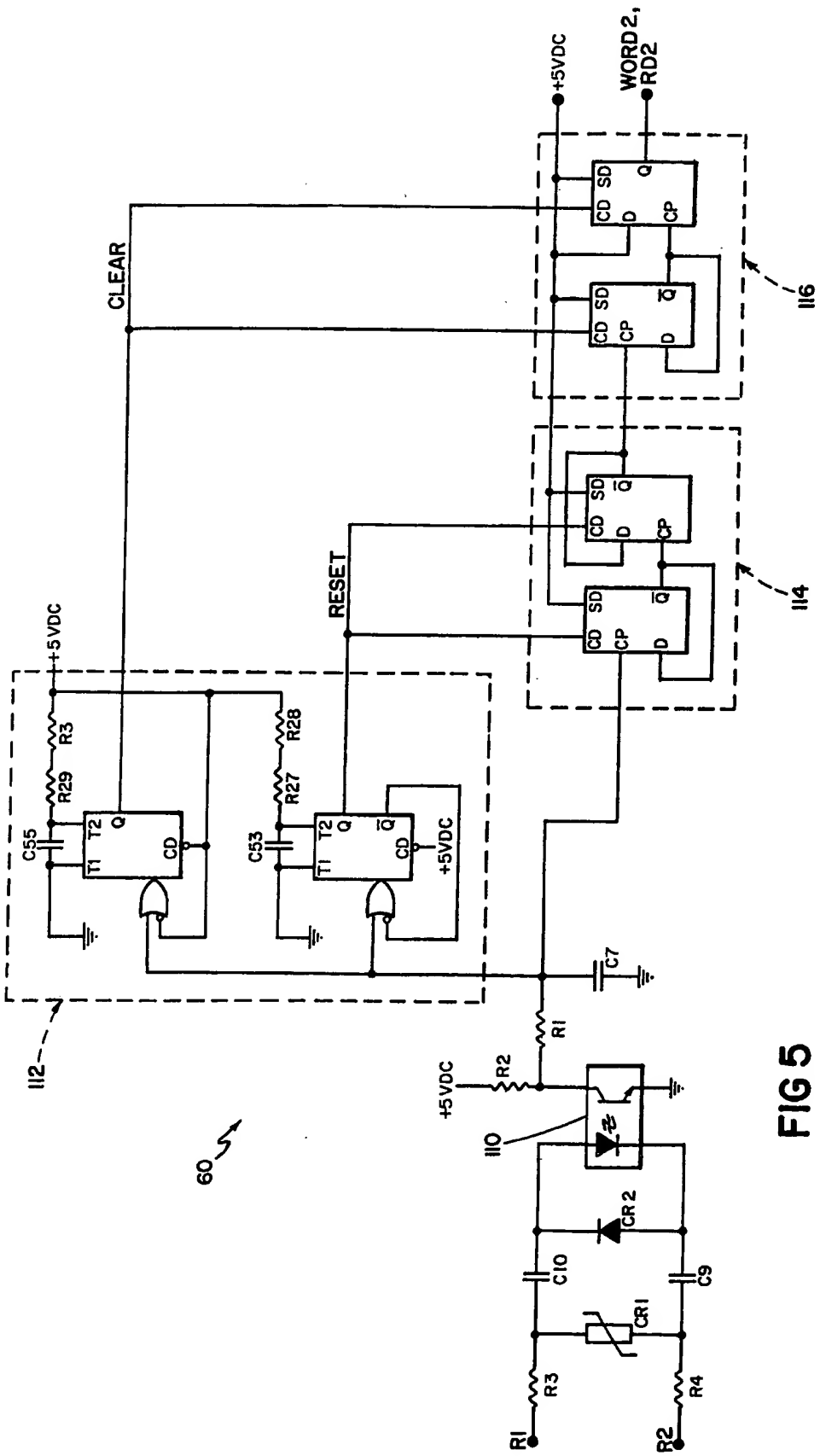

FIG 5

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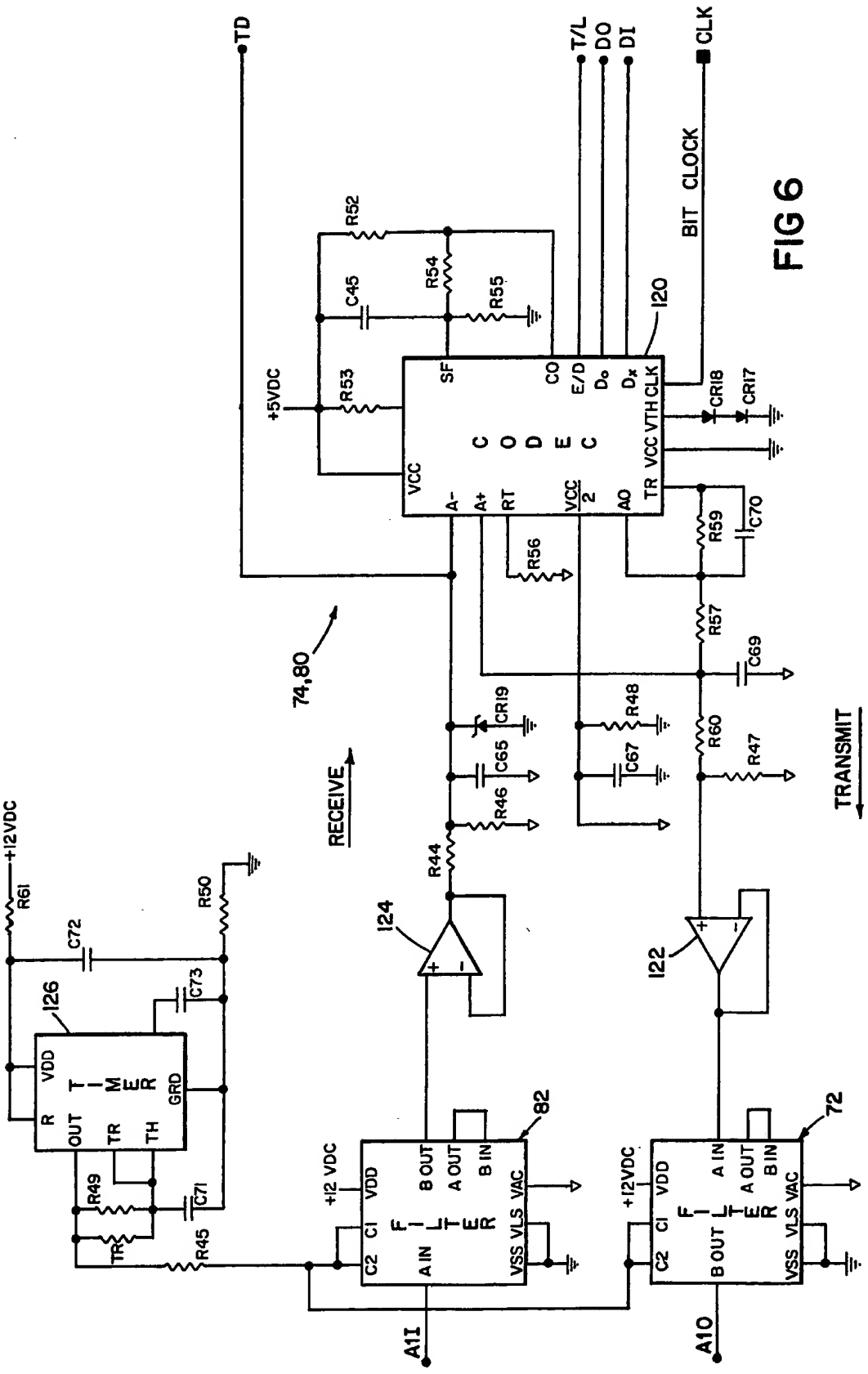

FIG 6

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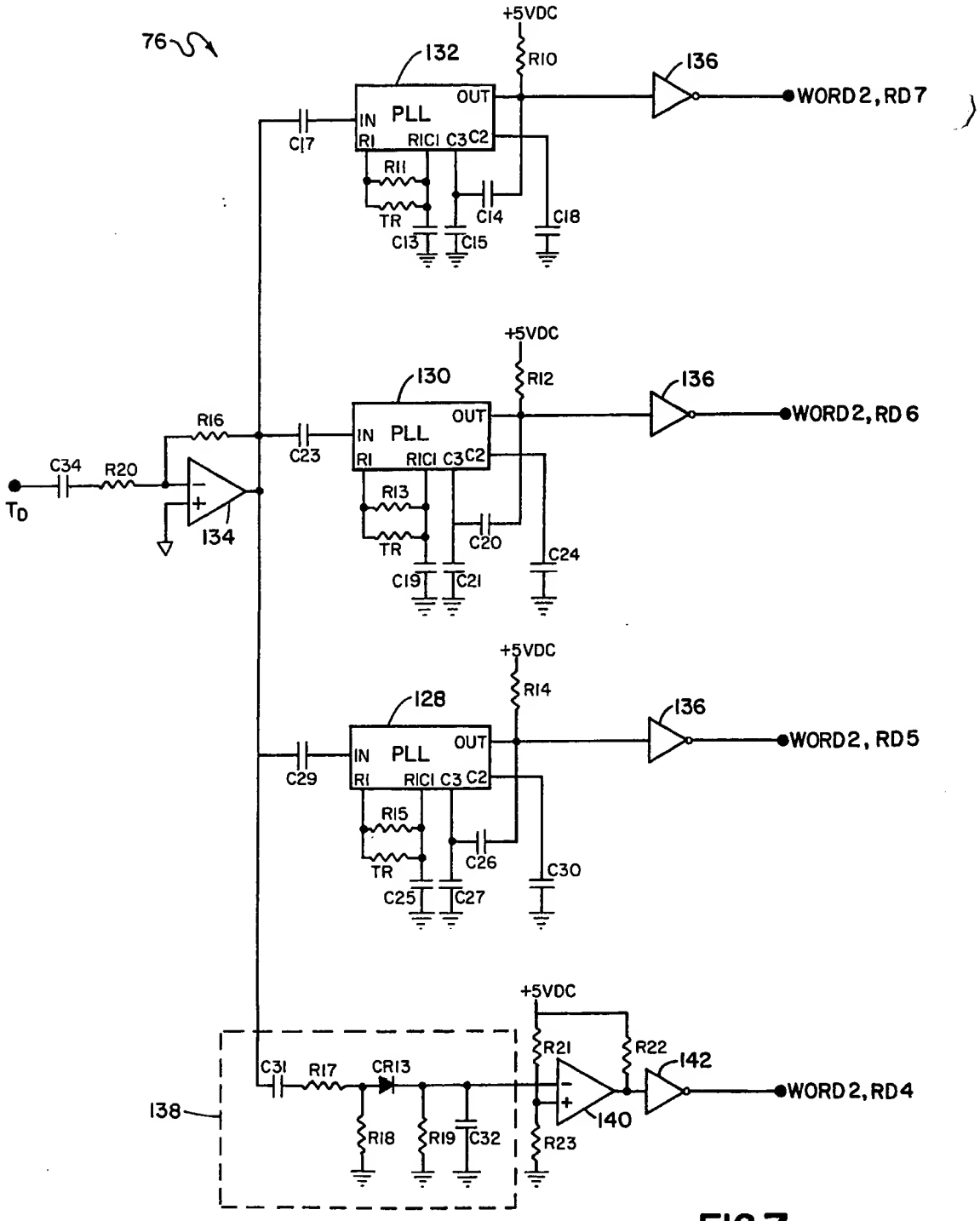

FIG 7

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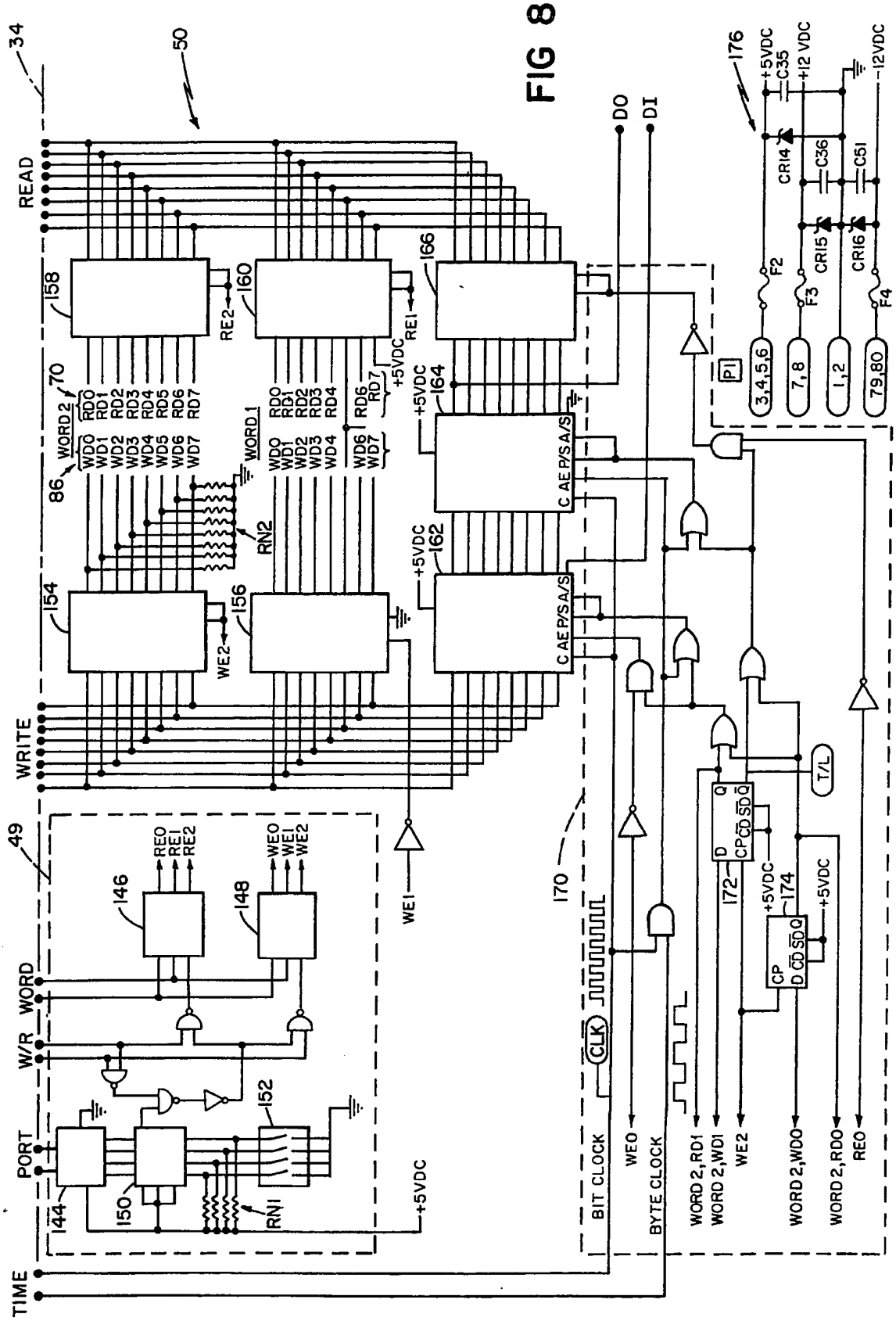
FIG 8



AUTOMATIC INCOMING CALL PROCESSING

FIG 9A

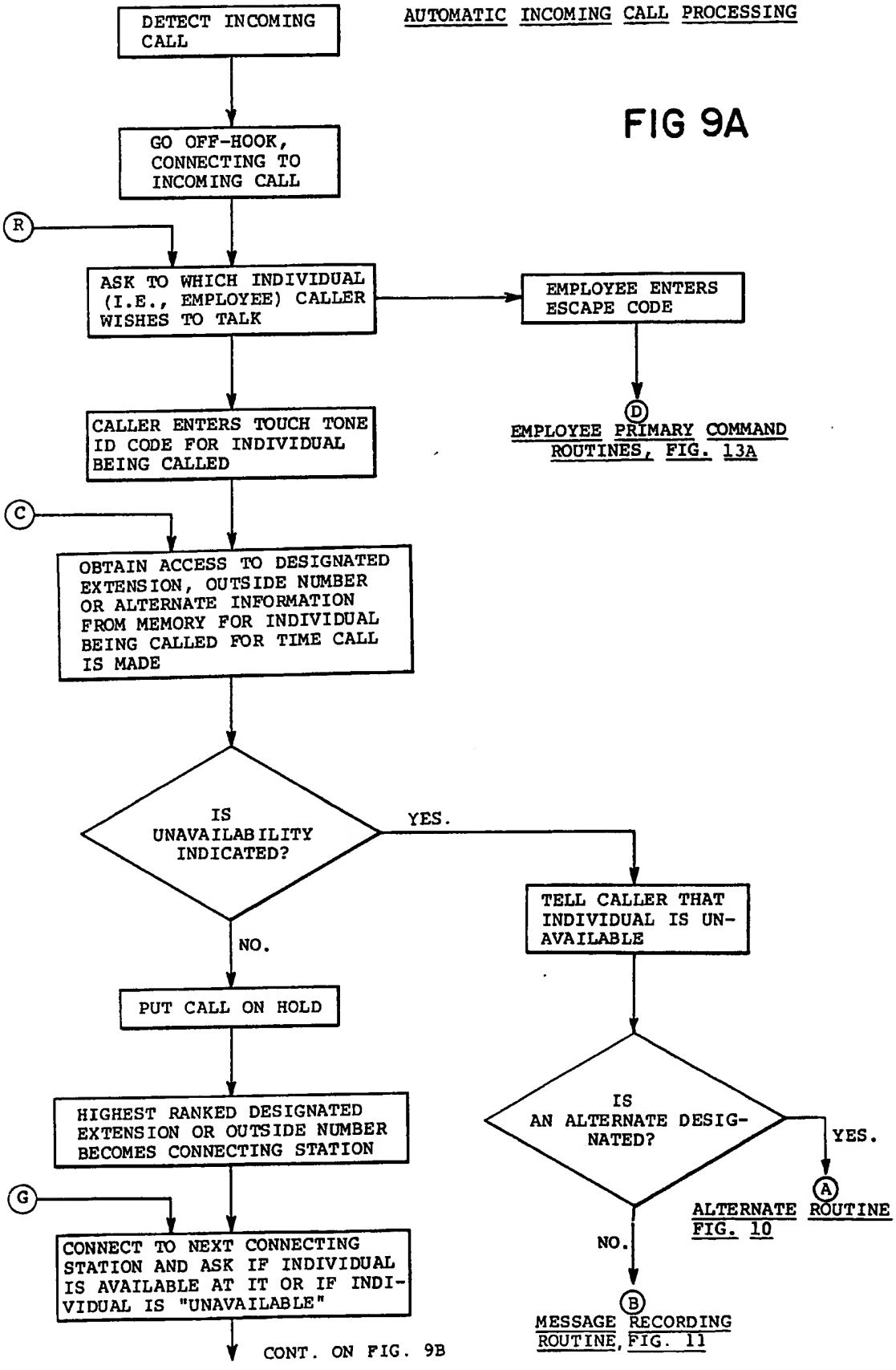
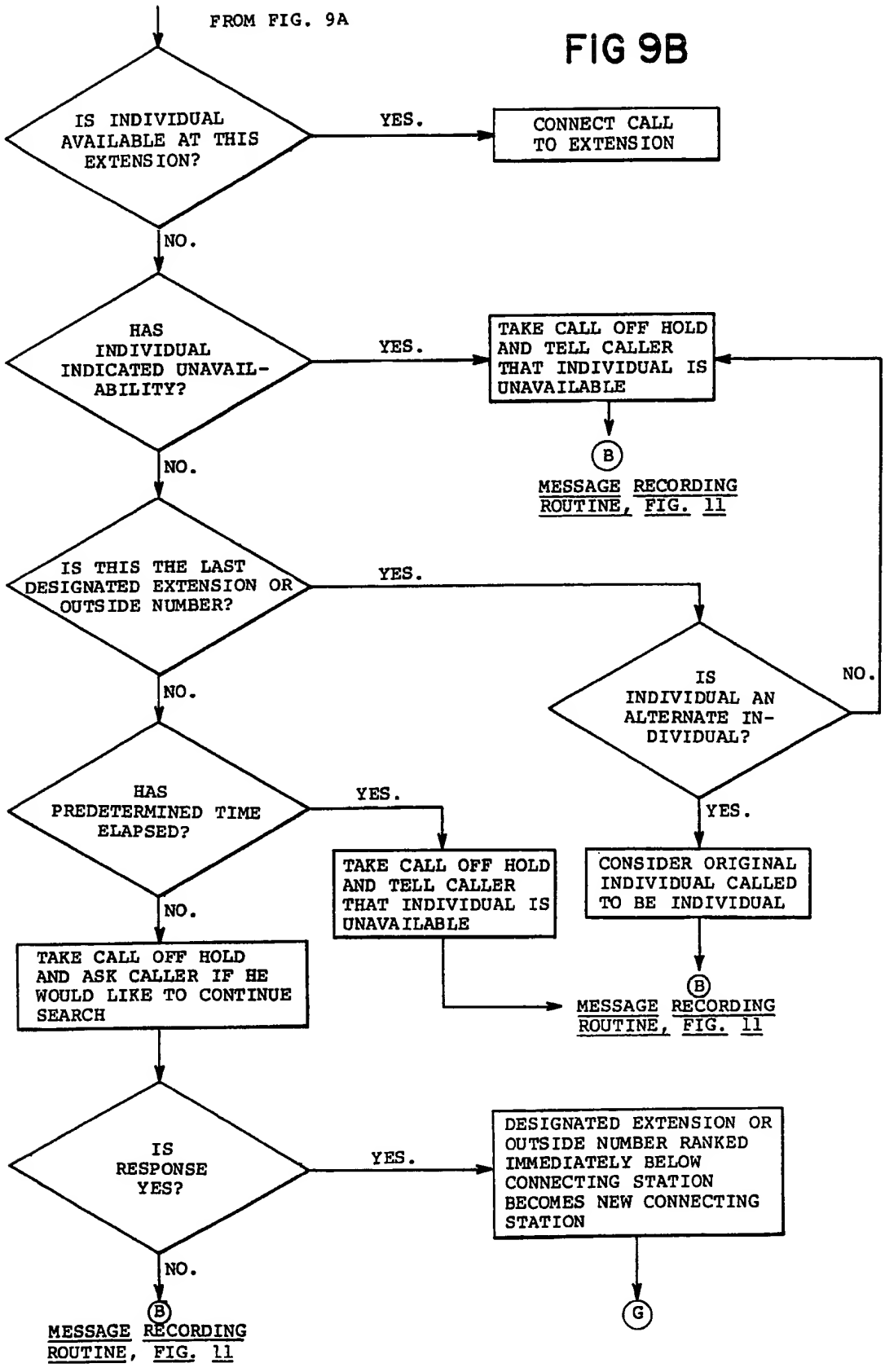


FIG 9B


FROM FIG. 9A
IS INDIVIDUAL AVAILABLE AT THIS EXTENSION?
YES.
CONNECT CALL TO EXTENSION
NO.
HAS INDIVIDUAL INDICATED UNAVAIL-ABILITY?
YES.
TAKE CALL OFF HOLD AND TELL CALLER THAT INDIVIDUAL IS UNAVAILABLE
B
MESSAGE RECORDING ROUTINE, FIG. 11
NO.
IS THIS THE LAST DESIGNATED EXTENSION OR OUTSIDE NUMBER?
YES.
IS INDIVIDUAL AN ALTERNATE IN-DIVIDUAL?
NO.
YES.
NO.
HAS PREDETERMINED TIME ELAPSED?
YES.
TAKE CALL OFF HOLD AND TELL CALLER THAT INDIVIDUAL IS UNAVAILABLE
CONSIDER ORIGINAL INDIVIDUAL CALLED TO BE INDIVIDUAL
NO.
TAKE CALL OFF HOLD AND ASK CALLER IF HE WOULD LIKE TO CONTINUE SEARCH
B
MESSAGE RECORDING ROUTINE, FIG. 11
IS RESPONSE YES?
YES.
DESIGNATED EXTENSION OR OUTSIDE NUMBER RANKED IMMEDIATELY BELOW CONNECTING STATION BECOMES NEW CONNECTING STATION
NO.
B
MESSAGE RECORDING ROUTINE, FIG. 11
G

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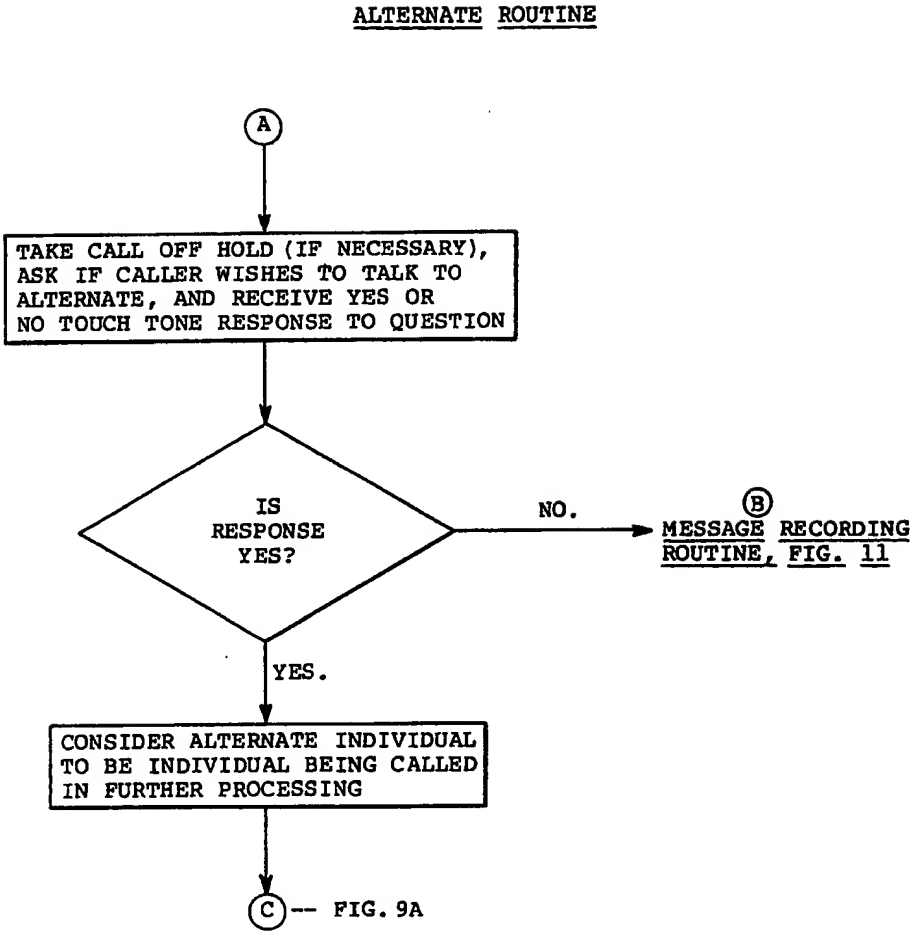

FIG 10

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MESSAGE RECORDING ROUTINE

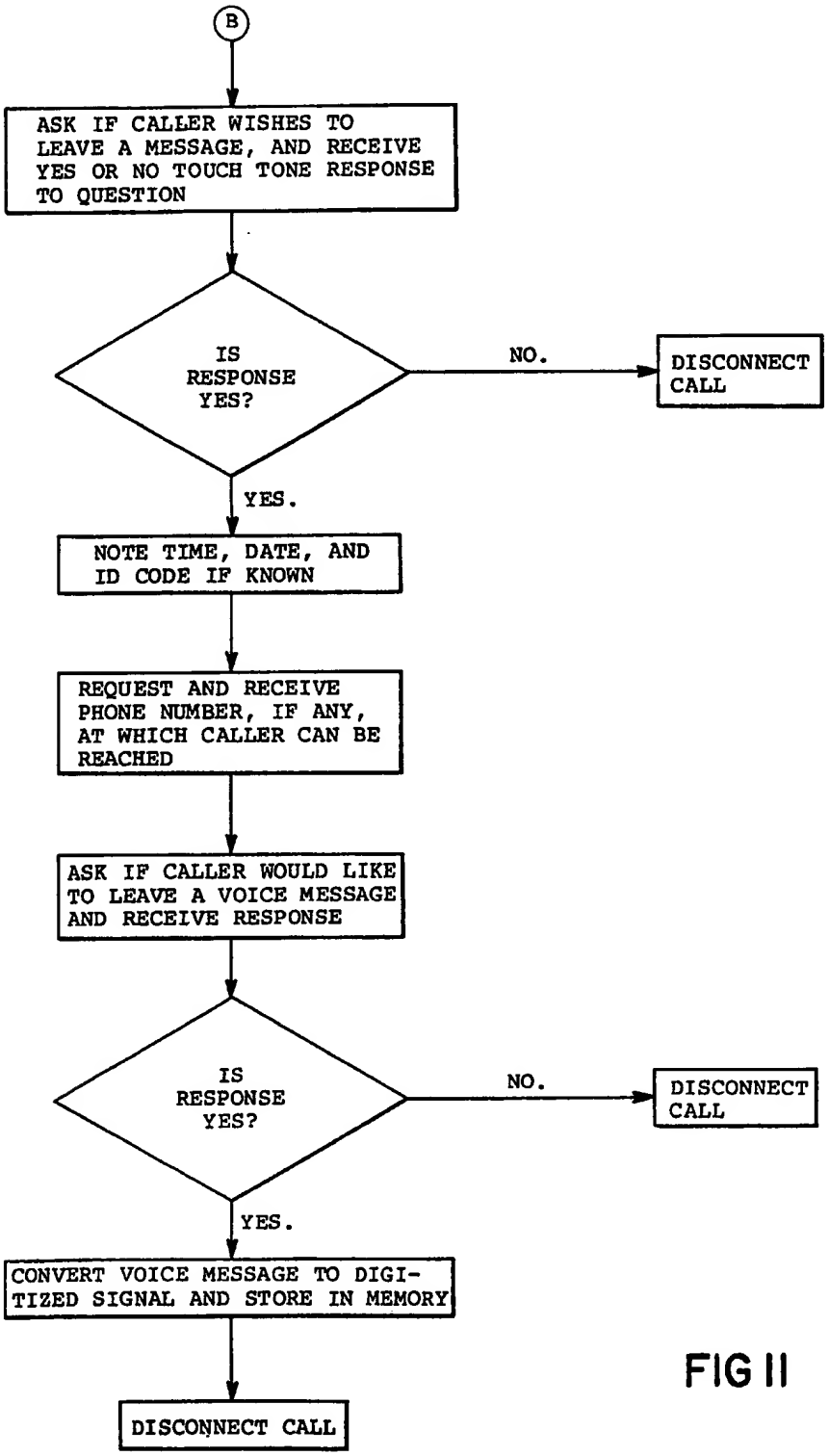
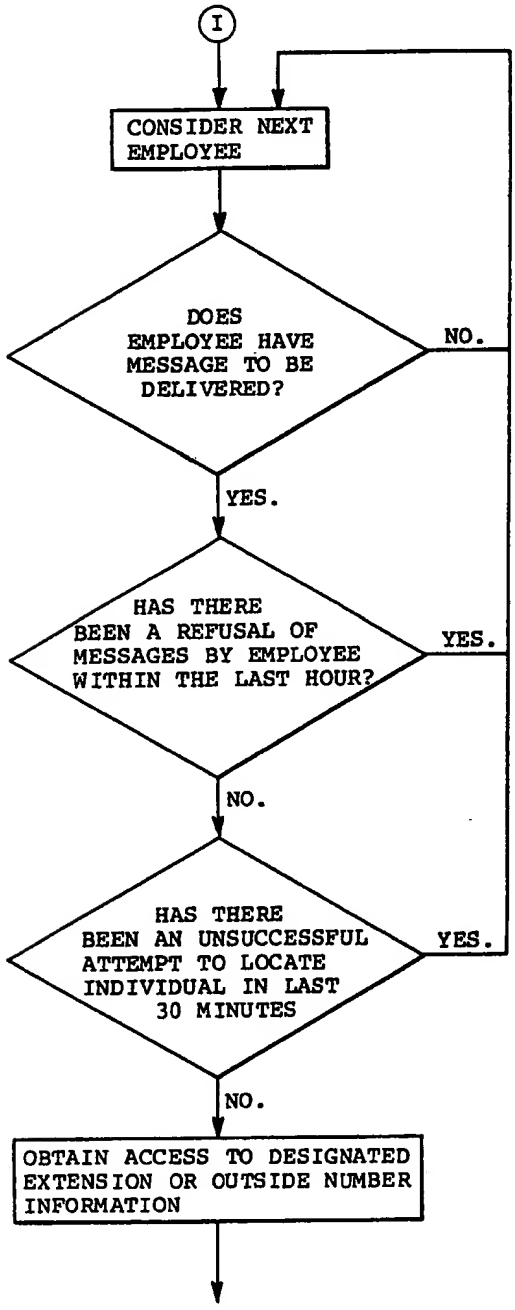


FIG 11

AUTOMATIC MESSAGE DELIVERY ROUTINE FOR ALL EMPLOYEES



CONT. ON FIG. 12B

FIG 12A

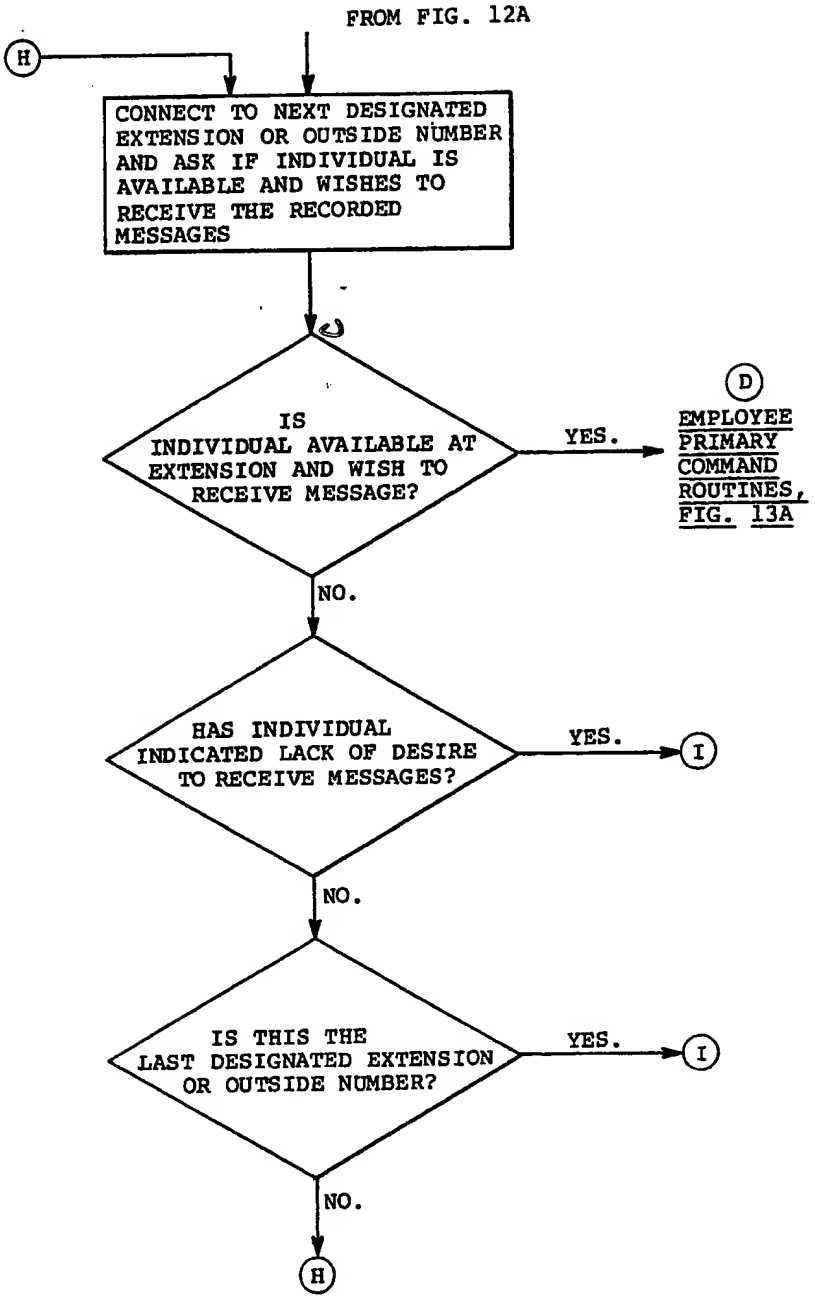

FROM FIG. 12A
H
CONNECT TO NEXT DESIGNATED EXTENSION OR OUTSIDE NUMBER AND ASK IF INDIVIDUAL IS AVAILABLE AND WISHES TO RECEIVE THE RECORDED MESSAGES
IS INDIVIDUAL AVAILABLE AT EXTENSION AND WISH TO RECEIVE MESSAGE?
YES.
D
EMPLOYEE PRIMARY COMMAND ROUTINES, FIG. 13A
NO.
HAS INDIVIDUAL INDICATED LACK OF DESIRE TO RECEIVE MESSAGES?
YES.
I
NO.
IS THIS THE LAST DESIGNATED EXTENSION OR OUTSIDE NUMBER?
YES.
I
NO.
H

FIG 12B

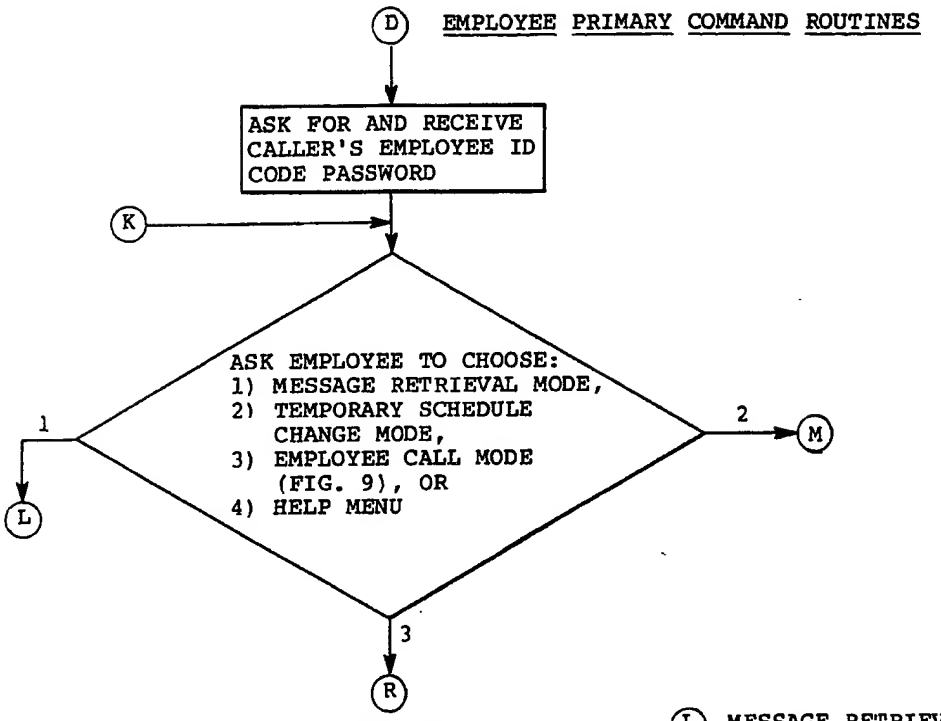


FIG. 9A

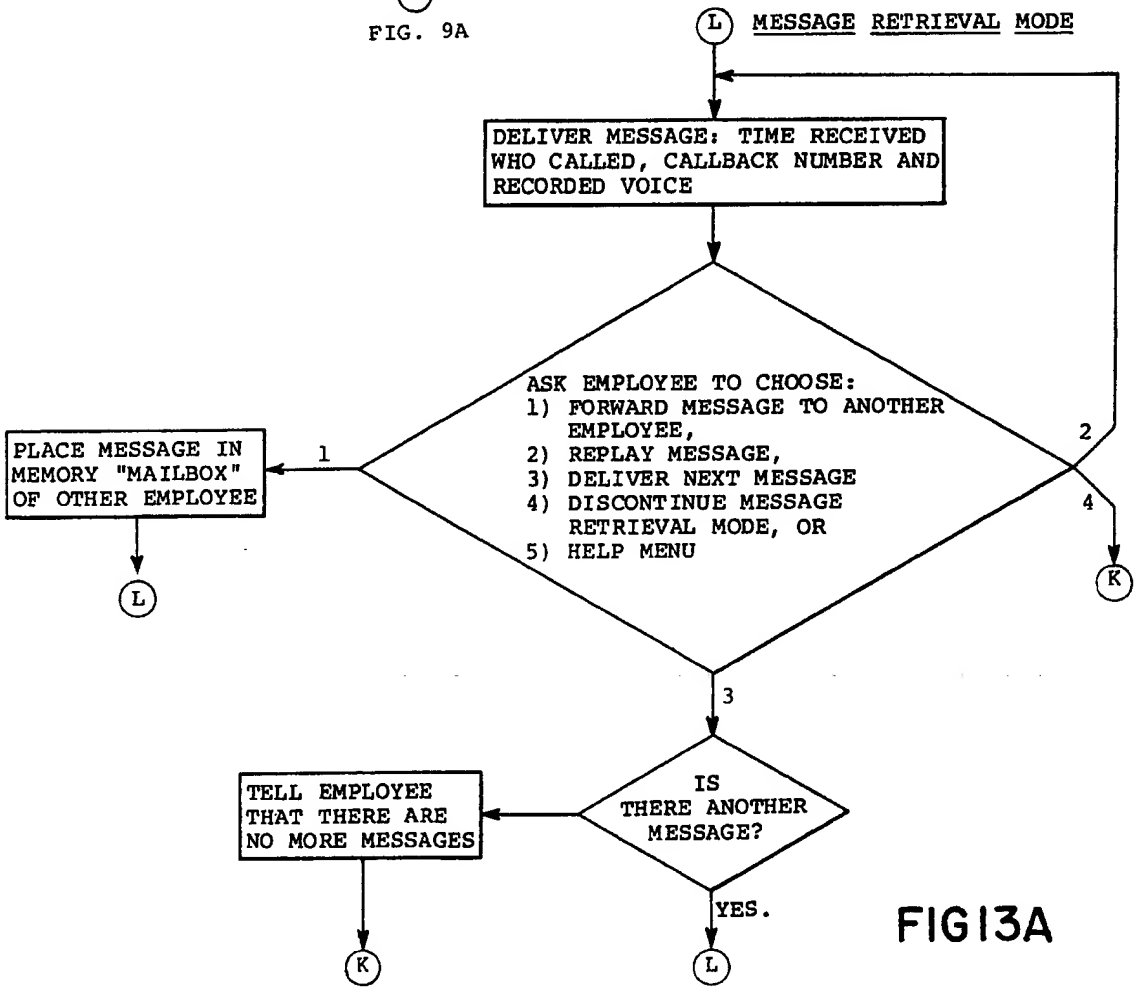


FIG13A

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SCHEDULE CHANGE MODE

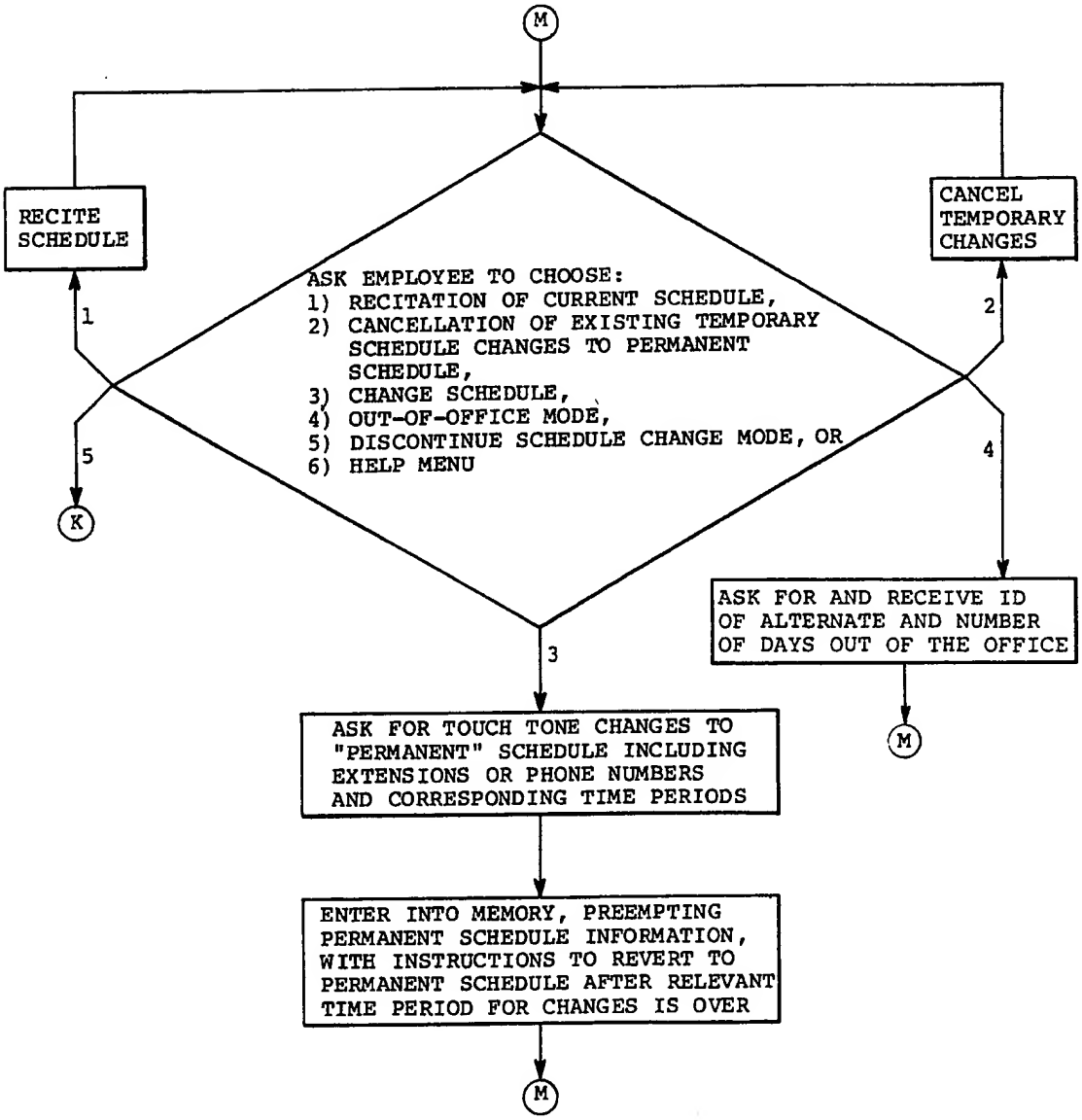

FIG 13B

SPECIFICATION

Automatically processing incoming calls

Field of the invention

The invention relates to processing telephone calls to a plurality of individuals accessible through a plurality of phone extensions having a common telephone number.

Background of the invention

A receptionist or operator typically answers the incoming calls to a common telephone number (or numbers) of a private branch exchange (PBX) of a business or other organization, determines whom each call is for, and transfers the call to the phone extension for that individual, possibly paging the individual over a public address system or taking a message if the individual is not present at the extension, and sometimes letting the phone extension ring until the caller hangs up. Problems involved with such systems are missed calls, "telephone tag" (i.e., a person returns a phone call at a time when the original caller is not available) and inaccurately transcribed messages. Also, it often may not be economical to provide enough operators to handle the volume of incoming calls at peak hours or to provide any operators after business hours, causing more problems in efficiently connecting the incoming calls to the individuals being called. In response to these problems, there has been development or call forwarding systems, in which a telephone user can have calls to one phone automatically switched to another phone, and systems that digitize and record a voice message left by a caller and attempt to deliver the message by calling the telephone station for the individual that the message is for (e.g., U.S. Patent No. 4,371,752).

Summary of the invention

In general the invention features improving processing of a telephone call for one of a plurality of individuals accessible through a plurality of phone extension stations or outside telephone number stations by a system that automatically answers a phone call, receives information identifying the individual being called, refers to a memory to obtain call handling information identifying at least one designated station at which the individual being called is likely to be present during the current time period, and causes the incoming call to be connected to a designated station.

In preferred embodiments, the call handling information for at least some of the individuals including a plurality of designated stations that are ranked, and the system searches for an individual by polling the phone stations sequentially in order of rank; some individuals are grouped, and the system searches for an accessible individual in a group, either according to fixed rank in the group or according to changing rank, the last individual having received a group phone call being assigned the lowest rank; an individual receiving calls through the system can call the system and enter an escape code permitting him to modify the designated stations in his call handling information stored in memory; the system includes means to record messages from the caller and to deliver them to the individual being called; the call handling information for an individual can indicate an alternate individual to receive the incoming phone calls; the individual being called can enter commands indicating that he is unavailable and does not wish to receive phone calls; the identity of the individual being called can be determined by asking questions identifying the subject matter related to the phone call and determining which individual should handle the call based upon the responses; the apparatus includes means for converting analog voice signals into digital voice signals and means for converting digital voice signals into analog voice signals; the apparatus includes means for converting dual-tone multi-frequency signals into digital signals and for converting digital signals into dual-tone multi-frequency signals; the apparatus includes means for interfacing with one or more ports of a PBX or other private telephone system; the apparatus includes means to put an incoming call on hold and to take the incoming call off of hold in the PBX system; the apparatus includes means for detecting call progress tones and ringing signals.

Description of the preferred embodiment

The structure and operation of the presently preferred embodiment of the invention will now be described after first briefly describing the drawings.

Drawings

Figure 1 is a block diagram showing apparatus according to the invention for automatically processing telephone calls, the apparatus being connected to a private branch exchange.

Figure 2 is a functional block diagram of a port circuit of the Figure 1 apparatus.

Figures 3- 8 are schematics of circuitry for elements of the Figure 2 port circuit.

Figures 9A- 13B are flow diagrams describing methods of automatically processing telephone calls by the Figure 1 apparatus.

Structure

Referring to Figure 1, there is shown automatic incoming telephone call processing apparatus 10 connected to private branch exchange (PBX) 12, in turn connected to the public telephone network 14. PBX

12 is connected to human operator/receptionist stations 16 and employee office stations (i.e., phone extensions) 18 located throughout an office or other place of business. Public network 14 is shown having connections to a plurality of private stations (i.e., telephones), classified in Figure 1 as customer stations 20 and employees field stations 22, which are private outside telephones at which employees of the business can be reached when they are not at work or are working in the field.

Port circuits 24 of automatic call processing apparatus 10 are connected to private branch exchange 12 at four exchange ports 26, which might normally be connected to any employee office station 18; ports 26 have associated with them a special direct-dial number or numbers permitting incoming calls to be directly routed to them without going through a human operator/receptionist station 16 (a standard feature of many private branch exchanges). Port input/output (I/O) controller 28 is connected to control interaction between port circuits 24 and host processor 30 and memory 32.

Each port circuit 24, shown in detail in Figures 2-8, interacts with PBX 12 and the remainder of apparatus 10, detecting incoming calls, dialing out, accepting and decoding touch-tone commands, converting digitized voice signals from memory into regular voice signals provided to PBX 12 and converting regular voice signals from PBX 12 into digitized voice signals stored in memory 32.

Port I/O controller 28 is a single-board computer (iSBC 88/25 from Intel) based on an 8088 processor. It communicates with port circuits 24 over local parallel bus 34. An eraseable and programmable read-only memory (EPROM) in controller 28 includes low level control algorithms.

Host processor 30 is a single board computer (iSBC 86/30 from Intel) based on an 8086 processor and contains the system's high level control algorithms loaded into its random access memory (RAM) and bus RAM 44 from memory 32 by a bootstrap program in an internal EPROM upon powering on. Host processor 30 also includes a battery powered clock on an SBX module to keep track of real time even if the system's power is disconnected.

Memory 32 includes intelligent disk controller 36 (DSD-5215 from Data Systems Design) driving both five and one-quarter inch, ten megabyte Winchester disk 38 (ST-412 from Seagate Technology) and five and one-quarter inch floppy disc 40 (SA-455A from Shugart). Winchester disk 38 contains the operating program of the system (including an MP/M-86 operating system from Digital Research, Pacific Grove, California), its data bases, and its vocabulary in the form of digitized speech.

Memory 32, port I/O controller 28 and host processor 30 communicate to each other over bus 42 (provided by a Central Data C2000 Multibus chasis) having bus RAM 44 (iSBC 056A bus RAM board from Intel) connected to it.

Host processor 30 is connected to control terminal 46 (DEC VT100), used for example to periodically update the operating program on Winchester disk 38 via floppy disk 40 and to copy the operating program onto floppy disk 40 to provide backup copies for the operating program.

Referring to Figure 2, a functional block diagram for a port circuit 24 is shown. Circuit 24 includes phone jack 48, connected to a port 26 of private branch exchange 12, at one end, and address decoding circuit 49 and bus interface circuit 50, connected to port I/O controller 28 over bus 34, at the other end. Phone jack 48 is connected via Bergstik 52 to current driver 54, switchhook control 56 (enabling incoming calls to be answered by apparatus 10 or outgoing calls to be initiated by apparatus 10, by simulating picking up a phone), auxiliary relay 58 (used instead of switchhook control 56 in key telephone systems and ground-start private branch exchanges) and ring indicator 60 (used to detect incoming calls). Hybrid transformer circuit 62 is connected between Bergstik 52 and input buffer 64 and output buffer 66. (Components 62, 64, 66 are used to isolate the circuitry from the telephone line and to provide over-voltage protection, to protect both the circuitry and the telephone system). Input buffer 64 is connected to dual-tone multi-frequency (DTMF) receiver 68 (to decode touch tone signals and provide a digital output on read bus 70) and to filter 72, providing an output to voice A/D circuit 74 (for digitizing voice signals) and to tone and energy detector 76 (to detect ringback, busy, and dial tones and voice signals). Ring indicator 60, voice A/D 74, and tone and energy detector 76 are also connected to provide digital outputs over read bus 70 to bus interface circuit 50. Output buffer 66 is connected to receive touch tone signals from DTMF sender 78 and analog voice signals from voice D/A circuit 80 via filter 82. Switchhook control 56, auxiliary relay control 58, DTMF sender 78, voice D/A circuit 80 and talk/listen control 84 (which controls voice D/A circuit 80 and voice A/D circuit 74) are all connected to respond to digital commands provided over write bus 86 from bus interface circuit 50.

Turning to Figure 3, switchhook control 56 and auxiliary relay control 58 each include a relay 88 (DIP 2 FORM C 12 V coil), connected respectively to lines Word 1, WD5 and Word 1, WD7 of write bus 86 via resistors R41, R10 and transistors 90. Auxiliary relay control 58 is typically disconnected from Bergstik 52, and jumpers must be connected to positions 7 and 8 to make it operational. Varistors 89 (V330-MA5B) provide telephone line protection. Current driver 54, for supplying a constant DC current between the tip and ring lines, includes transistors 91, 92 (TIP117), biased by current diode CR7, and diode bridge 93 (VM108).

Still referring to Figure 3, one of the transformer coils (T2220) of hybrid circuit 62 is connected to the input of low-noise operational amplifier 94 (NE5532) of input buffer 64, and the other coil is connected to the output of low-noise operational amplifier 96 (NE5532) of output buffer 66, also including relay 98 (DIP 2 FORM C 12 V coil), connected to receive TALK/LISTEN commands from line Word 2, RD1 of write bus 86 via resistor R51 and transistor 100.

Referring to Figure 4A, DTMF sender 78 includes decoder 102 (74LS139) connected to receive four bits provided over parallel lines Word 1, WD1, WD2, WD3 and WD0 of write bus 86 and to provide eight bits for

use by DTMF sender chip 104 (MK 5089 from Mostek) in providing standard touch tone signals to its output line A20 connected to output buffer 66.

Referring to Figure 4B, DTMF receiver 68 includes encoder chip 106 (SSI-202 from Silicon Systems), connected to receive audio signals from input buffer 64 at input line A2I and to provide a four bit word representing the received touch tones over parallel lines Word 1, RDO, RD1, RD2 and RD3 to read bus 70. The RXRDY output of chip 106 is connected to line Word 1, RD4 to indicate direction of a valid DTMF tone; monostable multivibrator 108 (MC14538B) is connected to clear the RXRDY output upon receiving an input on line RE1 indicating that the word has been read.

Referring to Figure 5, ring indicator 60 includes opto-isolator 110 (4N46) connected to input lines R1, R2 from Bergstik 52 via capacitors C9, C10, connected by varistor CR1 (V270-MA2A). The output of opto-isolator 110 is connected to dual precision monostable multivibrators 112 (MC14538B), acting as a timer providing CLEAR and RESET signals, and dual D flip-flops 114, 116 (74LS74), acting as a counter providing an output to read bus 70 at line Word 2, RD2 when there are varying signals having a frequency above 14 HZ.

Referring to Figure 6, it is seen that voice A/D circuit 74 and voice D/A circuit 80 are both incorporated in continuously-variable slope delta modulator/demodulator 120 (codec) (MC3417), connected to bus interface circuit 50 via serial digital input and output lines DI, DO and TALK/LISTEN line T/L (lines DI, DO, T/L being shown on Figure 2 as part of read bus 70 and write bus 86). Codec 120 is also connected to receive audio signals from and send audio signals to switched capacitor low-pass filters 72, 82 (MC145414P) via low-noise operational amplifiers 122, 124 (NE5532). Filters 72, 82 are connected to timer 126 (MC1455), providing 102,600 Hz clock pulses.

Referring to Figure 7, tone and energy detector 76 includes three phase-locked loop (PLL) circuits 128, 130, 132 (NE567) with appropriate resistors TR for detecting the indicated frequencies on filtered audio input line TD (from Figure 6) passed through low-noise operational amplifier 134 (NE5532). PLL circuits 128, 130, 132 are connected via inverters 136 to lines Word 2, RD5, RD6 and RD7 of read bus 70. The output of operational amplifier 134 is also connected to rectifying and filtering circuitry 138 and voltage comparator 140 (LM339), providing an output indicating the presence of energy on the incoming audio line to line Word 2, RD4 of read bus 70 via inverter 142.

Referring to Figure 8, it is seen that local bus 34 (the individual lines of which are shown spread out along the top of Figure 8) includes bit and byte timing lines, six address lines to address decoding circuit 49 and eight write lines and eight read lines to bus interface circuit 50. Address decoding circuit 49 includes decoder/demultiplexer 144 (74LS139), connected to four-bit comparator 150 (74LS85) and address switch 152, to connect the proper port circuit 24 to I/O controller 28, and drivers 146, 148 (also 74LS139 decoder/demultiplexers) connected to enable the proper read or write register in bus interface circuit 50. Bus interface circuit 50 includes registers 154 (74LS244), 156 (74LS373) (connected in parallel to receive Word 1 and Word 2 respectively over the write data lines of bus 34), registers 158, 160 (74LS244) (connected in parallel to provide Word 1 and Word 2 respectively to the read data lines of bus 34) and universal shift registers 162, 164 (MC14034B) and register 166 (74LS244), for buffering voice data received from and sent to codec 120 over lines DI, DO serially and sent to and received from I/O controller 28 over bus 34 in parallel one byte at a time. The enabling pins of registers 154-160 are connected directly or through inverters to the outputs of drivers 146, 148, and the enabling pins of registers 162, 164, 166 are connected through TTL logic circuitry 170, including flip-flops 172, 174 (74LS74).

Power circuit 176 is also shown in Figure 8; it is powered by a Powertec 6E5-BBA-17BC power supply, as are host processor 30, I/O controller 28, disk controller 36 and bus RAM 42.

TALK/LISTEN control is provided to codec 120 (Figure 6) and relay 98 (Figure 3) from bus interface 50 over line T/L.

The following table contains descriptions of the resistors, capacitors and diodes used in the port circuits:

Component Table

	Resistors	*Ohms*
	R9	22
	R61	100
	R1	120
	R23	150
	R44-45, 50, 57	270
	R42, 48	330
	R24	390
	R47	680
	R7, R36	820
	R25, 39-41, 43, 51	1 K
	R2, R31-32, 34, 53	1.2 K
	R22	2.2 K
	R8	2.7 K
	R10, 12, 14, 17, 37	3.3 K
	R20, R60, R33	4.7 K
	R15	5.6 K
	R13	8,2 K
	R11, 46, 52, 56	10 K
	R59	12 K
	R21, 49, 62	15 K
	R30, R16	22 K
	R54	47 K
	R19	100 K
	R18	150 K
	R28	220 K
	R29	470 K
	R55	1.5 M
	R26	10 M
	R5, R6	10
	R3, R4	100 K
	R35, R38	600
	R27	1.2 M
	RN2 (10-pin resistor network)	2.7 K
	RN1 (8-pin resistor network)	10 K
	Capacitors	*Microfarads*
	C15	4.7
	C21, C27	3.3
	C11	.01
	C67, C70, C34, C17, C23 C29, C31, C14, C20, C26, C7, C56, C59, C2, C48, C49, C47, C58, C60, C61	
	C63, C64, C66, C54, C37	.1
	C8, C9	.10
	C71	.00051
	C32, C72	1
	C10, C73	.01
	C62, C74, C69	.022
	C53, C55, C65	.15
	C68, C13, C19, C25 C18, C30, C24, C45	.33
	C35, C36, C51	47
	C12	.5
	C75	.0022

Diodes	*Description*
CR2, CR8, CR9, CR16	1A-IF 400V-VR
CR10, CR11, CR13	Schottky Hi Speed Low Curr.
CR15, CR20	13V Zener, IN5243
CR14	5.6 V Zener, 1N5232, .5 MW
CR19	5.1 V Zener, 1N5231B
CR5, CR6	75 V Zener, 1N6292A
CR7	Curr. reg. 1.5 MA
CR12, CR17, CR18	X, Silicon

Operation

The overall operation of telephone call processing apparatus 10 will be described first, with reference to Figure 1.

In operation, upon powering on the system, the bootstrap routine in the EPROM of host processor 30 automatically loads the operating program from Winchester disk 38 into the RAM of host processor 30 and bus RAM 44. The operating program includes low level routines by provided by the MP/M-86 system and the high level algorithms for the routines described in detail below and in Figures 9-13.

Incoming calls to a direct-dial number or numbers associated with ports 26 are handled by apparatus 10 simultaneously on a time-sharing basis. Port I/O controller 28 receives commands from host processor 30 and converts them into commands to the port circuit 24 enabled by the appropriate signal on the address lines of local bus 34. Throughout operation, port I/O controller 28 periodically polls port circuits 24 to see if the output of ring indicator 60 at line WORD 2, RD2 indicates an incoming call; when this happens, I/O controller 28 provides a signal indicating this to processor 30.

In relaying a block of information from memory 32 to port I/O controller 28, host processor 30 sends commands to disk controller 36 to load the block of information into bus RAM 44, and sends commands to port I/O controller 28 indicating that the block of information is temporarily stored in bus RAM 44, and is available for removal by port I/O controller 28 one byte at a time.

Similarly in relaying information from port I/O controller 28 to memory 32, host processor 30 sends commands to port I/O controller 28 to send the information to bus RAM 44 one byte at a time, and then sends commands to disk controller 36 to load the information in bus RAM 44 into Winchester disk 38.

The operation of port circuits 24 in interfacing with PBX 12 and in relaying information between it and the remainder of apparatus 10 will now be described with particular reference to Figures 2-8. When PBX 12 provides a ringing voltage to jack 48, the low-frequency alternating current (AC) portion of the signals is passed over lines R1, R2 (Figure 3) and through capacitors C9 and C10 (Figure 5) to opto-isolator 110, and when the signal applied to opto-isolator 110 is greater than about 50 V rms, it creates an output train of pulses with a frequency identical to the applied signal and a TTL-compatible voltage swing. Upon sensing the train of pulses, dual monostable multivibrators 112 generate a CLEAR signal, 74 msec long, and a RESET signal, 213 msec long, and flip-flops 114, 116 act as a gated counter, counting the output pulses of opto-isolator 110, and providing an output at line WORD 2, RD2 of bus 70 after counting four pulses; the fourth pulse is counted during the period after the CLEAR signal has ended and before the RESET signal has ended only if the ring signals have a frequency above 14 Hz. Thus ring indicator 60 is not triggered by normal dial-pulsing, which has a frequency of 10 Hz.

After I/O port controller 28 has detected a ring indicator output at line WORD 2, RD2 and has received a command from host processor 30 to cause a port circuit 24 to go off-hook (i.e., simulate picking up a phone), this is done by providing a command to switchhook control 56 (Figure 3) over line WORD 1, WD5, turning on its transistor 90 and relay 88 and closing the switch connected to its relay 88. When this happens, current driver 54 is activated, causing it to supply a constant DC current, while allowing audio frequencies to pass through to hybrid transformer circuit 62 with minimal attenuation. Current diode CR7 biases transistors 91 and 92. The 0.6 volt base-emitter drop from transistor 91 creates a constant current of about 27 mA in resistor R9. This current is driven out to the line by transistor 92. Diode bridge 93 allows proper operation even if the telephone line polarity is reversed.

In interfacing with PBX 12, e.g., in placing calls and in determining when a phone has been picked up, it is necessary to detect the following call progress tones, which are provided by the following combinations of frequencies: dial tone (350 Hz and 440 Hz), busy tone (480 Hz and 620 Hz) and ringback tone (440 Hz and 480 Hz). These tones are passed through input buffer 64 and filter 72 (Figure 2) and, referring to Figure 7, are detected by phase-locked loop circuits 128, 130, 132, which are adjusted by selecting appropriate trimming resistors TR to operate at 350, 460, and 610 Hz, respectively. Circuit 130 detects both 440 and 480 Hz signals, because the phase-locked loop circuits have wide detection bandwidths. A dial tone causes an output at lines WORD 2, RD6 and RD7; a busy tone causes an output at lines WORD 2, RD6 and RD5, and a ringback tone causes an output at line WORD 2, RD6 only.

Energy detection is also performed by detector 76 to verify the above-mentioned tones, to trigger the beginning and ending of voice digitization, and to detect conversation. This is performed by circuitry 138 (Figure 7), which rectifies and filters the incoming audio signals on line TD from filter 72 (Figure 2), and by comparator 140, which compares the small direct current voltage produced by circuitry 138 against a fixed reference. When the voltage exceeds the reference voltage, the output of comparator 140 goes low, causing an output from inverter 142 at line WORD 2, RD4.

Touch tones used to dial out and interface with PBX 12 are provided by DTMF sender 78 (Figure 4A). The tones are determined by four parallel bits at lines WORD 1, WD0, WD1, WD2, WD3 provided to decoder 78, which generates eight parallel bits used by DTMF sender chip 104, which transmits a tone to a port 26 via audio output line A20 when sender chip 104 is enabled by a TXRDY input at line WORD 1, WD4.

Referring to Figure 4B, incoming touch tones on audio input line A2I from input buffer 64 are decoded by DTMF receiver 68. A four-bit word is provided by encoder chip 106 over parallel lines WORD 1, RD0, RD1, RD2, RD3. When a valid tone is detected by chip 106, an RXRDY output is provided at WORD 1, RD4, to indicate that the word is ready to be read. As the four-bit word is being latched into register 160 (Figure 8) for reading by I/O controller 28, a signal is provided at line RE1, and the RXRDY output is cleared by the resulting signal provided to chip 106 by monostable multivibrator 108.

Referring to Figure 6, codec 120 digitizes incoming voice messages at audio input line A1I, providing a serial digital input on line DI to bus interface 50, and converts serial digital message signals on serial digital output line DO into voice messages provided to audio output line A10 for transmission to PBX 12. The bit clock provided to codec 120 causes the audio signal to be sampled at 24,000 bits per second. Codec 120 is set to encode (listen) or decode (talk) via TALK/LISTEN signals on line T/L. While listening, relay 98 (Figure 3) automatically short circuits the output of codec 120. Timer 126 (Figure 6) provides a 102,600 Hz clock signal to switched capacitor filters 72, 82, setting their upper frequency cutoff at about 2800 Hz. Input filter 82 prevents aliasing of the voice signal when it is digitized, while output filter 72 smooths the voice signal when it is converted from digital to analog form.

Referring to Figure 3, operational amplifiers 94, 96 supply gain and buffering for the voice and tone signals. These signals are brought in from the telephone line by hybrid transformer circuit 62, which isolates the circuitry from the telephone lines, and separates the transmit and receive paths.

Referring to Figure 8, port circuit 24 communicates with I/O controller 28 over the parallel lines of local bus 34 at the top of the drawing. One of the four port circuits 24 is enabled by providing the appropriate input to the PORT address lines to decode 144. Whether information is being written to or read from registers 154-166 is determined by the input to the W/R address lines. Whether WORD 1 registers 156, 160, WORD 2 registers 154, 158 or the digitized voice (WORD 0) registers 162, 166 are connected to the WRITE, READ data lines is determined by the input to the WORD address lines.

Information written to or read from registers 154, 156, 158, 160 provide the control signals for interfacing with PBX 12 as described above. Registers 162, 164, 166 are used to buffer digitized voice data provided to and received from codec 120 in serial form and provided to and received from I/O controller 28 one byte at a time. Digital voice data being written to port circuit 24 are "double-buffered"; that is, each byte is latched into register 162 synchronously, and then transferred to buffer 164 synchronously. Once latched into buffer 164, data are shifted out serially over serial digital output line DO at the rate required by codec 120. Data from codec 120 over input line DI are shifted into register 162 serially, and then transferred synchronously to register 164 and register 166, from which the data are provided to local bus 34. TTL logic circuitry 170 controls the parallel and serial shifting, and provides a "loopback" test mode in which data sent to a port circuit 24 can be read back directly, by-passing the voice digitizer.

The 24 K Hz bit clock and 3 K Hz byte clock are provided by local bus 34.

Turning now to Figures 9a-13B, the method of automatically processing incoming telephone calls by apparatus 10 will be described. Incoming calls from customer stations 20 are either made to the general telephone number for the business, in which case they are handled by human operators at stations 16, or they are made to a special direct dial number or numbers associated with ports 26 and provided to certain callers along with the identification codes for the employees with whom they primarily deal, so that their calls can be handled by automatic phone call processing apparatus 10.

Assuming that an incoming call is made to one of the direct-dial numbers associated with apparatus 10, switchhook controller 56 simulates a phone at that port 26 going "off hook", connecting the incoming call to apparatus 10. Using a digitized voice message stored in memory 32, apparatus 10 asks the caller to which individual (i.e., employee) the caller wishes to talk, requesting that the caller enter the identification (ID) code for the employee using touch tone commands on his telephone. Assuming that the caller enters an ID code (and does not enter an escape code, causing apparatus 10 to go into the primary command routines, something described in more detail below and on Figures 13A, B), apparatus 10 obtains access to the call handling information stored in its memory 32 for the individual being called for the current time. This information includes a list of the extensions 18 designated as those at which the individual is likely to be present along with outside telephone numbers (i.e., numbers for employee field stations 22) at which the caller can be reached and information identifying an alternate individual who could take the call for the employee if he is unavailable. This information is stored on Winchester disk memory 38 and is called the "permanent schedule". The information on the permanent schedule also contains different extensions and outside telephone numbers for different times of the day and different days of the week. For each time

period, the extensions and outside numbers are ranked in order of likelihood of being present. The permanent schedule can also include an indication that the individual is unavailable during particular time periods. If the schedule indicates that the individual being called is unavailable, apparatus 10 tells the caller that the individual is unavailable and executes the alternate routine (Figure 10), if there is an alternate designated; if not, apparatus 10 executes the message recording routine (Figure 11).

Assuming that the schedule indicates that the individual being called should be reachable at one of a plurality of ranked extensions, apparatus 10 puts the incoming call on hold. Apparatus 10 then provides the proper signals to PBX 12 to connect a port 26 to (i.e., to place a call to) the first designated extension. When a connection has been made to the extension (i.e., when somebody picks up the phone), apparatus 10 waits until it detects the energy associated with the person answering the phone and saying "Hello" or the equivalent, and asks if the individual being called is available at that extension or if the individual is "unavailable", and receives a touch tone answer to the question. Assuming that the individual is available at this extension and desires to receive the phone call, apparatus 10 provides the proper signals to PBX 12 to cause the incoming call, which is still on hold, to be connected to that extension. If the individual is not available at the extension, and has not indicated unavailability, and if five minutes has not elapsed since answering the incoming call, apparatus 10 takes the call off of hold and if the caller would like the search to continue. If the response is no, apparatus 10 executes the message recording routine (Figure 11). If the response is yes, apparatus 10 provides signals to PBX 12 causing it to be connected to the next extension on the list of extensions for the individual being called, and again asks if the individual being called is available at that extension or if the individual is unavailable. This procedure continues until apparatus 10 has tried all extensions listed on the schedule for the current time period, or until five minutes has elapsed or until the caller says that he does not wish to continue the search for the individual being called. If during the search apparatus 10 receives an indication from the individual being called that he or she in unavailable, apparatus 10 informs the caller that the individual is unavailable and proceeds to execute the message recording routine (Figure 11). If apparatus 10 has tried all designated extensions for the current time period, and there is an alternate individual listed to receive calls for the individual, apparatus 10 proceeds to execute the alternate routine as described in Figure 10.

Referring to Figure 10, in executing the alternate routine, apparatus 10 asks the caller if he or she wishes to talk to the alternate and receives a yes or not touch-tone response to the question. If the response is no, apparatus 10 proceeds to execute the message recording routine (Figure 11). If the response is yes, apparatus 10 obtains access to the alternate individual's schedule information and considers the alternate individual to be the individual being called and proceeds through the automatic search for the alternate individual at the extensions designated in his or her schedule. (In the most preferred embodiment apparatus 10 tries only the highest ranked station listed in the alternate's schedule.) If the alternate individual cannot be reached, if the alternate individual's schedule indicates unavailability or if the alternate individual signals unavailability, apparatus 10 proceeds to execute the message recording routine (Figure 11), receiving a message for the original individual being called. (Although not indicated on Figure 9A, if an alternate is unavailable, apparatus 10 does not attempt to reach an alternate's alternate.).

Referring to Figure 11, the message recording routine will now be described. First apparatus 10 asks if the caller wishes to leave a message and receives a yes or no touch-tone response to the question. If the response is no, apparatus 10 disconnects the call. If the response is yes, apparatus 10 notes the time, date and ID code (if caller is an employee, and the ID code has been entered) and requests and receives the phone number, if any, at which the caller can be reached, and the caller enters the number by touch-tone command. Apparatus 10 then asks the caller if he or she would like to leave a voice message and receives a touch-tone response. If the response is no, the incoming call is disconnected, and the message is merely the caller's phone number, the time the message was taken and the employee ID code (if entered). If the response is yes, apparatus 10 provides a beep and converts the voice message delivered by the caller to a digitized signal and stores it in memory 32 in a "mailbox" for the individual being called.

The automatic message delivery routine for all employees is shown in Figures 12A, B. Apparatus 10 continually attempts to deliver calls, taking each employee in sequence. If an employee does not have any messages, apparatus 10 moves on to the next. When an employee with a message in his mailbox is identified, apparatus 10 searches for that employee unless there has been a refusal of messages within the last hour or an unsuccessful attempt to locate the employee within the last 30 minutes.

Searching is carried out by connecting to the first designated extension or outside number and asking if the individual is present and wishes to receive the recorded message. If the individual is available at the extension and wishes to receive the message, apparatus 10 proceeds to execute the employee primary command routines (Figure 13A), permitting the employee to request delivery of the message. If the individual has indicated a lack of desire to receive messages, apparatus 10 moves on to the next employee. If the individual has not been located at this extension, apparatus 10 then tries the next extension or outside number on the list and continues this process until it has reached the individual or until it has tried all the designated extensions and outside numbers on the list, in which case apparatus 10, moves on to the next employee, eventually returning to this employee.

Referring to Figures 13A, B, the employee primary command routines are described. The employee obtains access to the employee command routines by entering an escape code when apparatus 10 initially asks the caller to which individual the caller wishes to speak, or by indicating a desire to receive messages.

Apparatus 10 asks for and receives the employee's ID code password and asks the employee to select one of the following: (1) the message retrieval mode, (2) the temporary schedule change mode, (3) the employee call mode, or (4) the help menu, and receives the appropriate touch-tone command from the caller.

If the employee call mode, used to talk to another employee, is selected, the automatic call processing routine shown in Figures 9A, B is executed, and, if a message is left, the caller will be identified by his ID code without the necessity of a voice message.

If the help menu is selected, apparatus 10 recites all options available to the employee, and what touch-tone buttons should be pressed to enter the various modes.

If the caller indicates the message retrieval mode, and there is a message, apparatus 10 recites the time of the message, who called (if any employee ID code has been entered) and the call back number and plays back any digitized recorded message, converting it to a regular voice message and providing it to the extension.

After this, apparatus 10 asks the employee to select one of the following options: (1) have the message forwarded to another employee (in which case the message is placed in the mailbox in disk memory 38 for that individual, and will be delivered according to the Figures 12A, B routine), (2) have the message replayed, (3) have the next message delivered, (4) discontinue the message retrieval mode, or (5) the help menu. If the message is not going to be replayed or forwarded, it is deleted. If the employee has elected to receive further messages, and if there are further messages, they are delivered in sequence as just described. If there are no further messages, the employee is informed of this, and this is the end of the message retrieval mode.

In the schedule change mode, the employee is asked to select one of the following options: (1) recitation of the employee's current schedule, (2) cancellation of the existing temporary schedule changes to permanent schedule, (3) change schedule, (4) out-of-office mode, (5) discontinue schedule change mode, or (6) the help menu. If the employee selects (1) or (2), these functions are carried out, and the six options are presented once again. If the employee has indicated that he wishes to change his schedule, apparatus 10 asks for touch-tone commands indicating the temporary changes to be made to the permanent schedule, including commands indicating the extensions or phone numbers, alternate individuals and the corresponding time periods. Apparatus 10 enters this into its memory, preempting the permanent schedule information, with instructions to revert to the permanent schedule after the relevant time period for the temporary schedule has passed.

If the employee selects the out-of-office mode, e.g., if he will be away for several days, apparatus 10 requests and receives information identifying an alternate individual, and the number of days that the individual will be away; this information is then recited to anyone attempting to place a call to this individual. After this information has been entered, the employee is once again presented with the six options.

After an employee has indicated that he wishes to discontinue the message retrieval mode or schedule change mode, he will be presented with the original options of the primary command mode.

An employee can end the primary command routines at any time, even when in the message retrieval mode or schedule change mode, by entering the appropriate touch-tone command. If one does not formally end the primary command routines by entering the appropriate signal, but merely hangs up, apparatus 10 formally ends after a predetermined period of time.

Selecting the help menus in the employee primary command routines causes apparatus 10 to recite the button numbers necessary to select available options.

Other embodiments

Other embodiments of the invention are within the scope of the appended claims.

For example, an employee's call handling information can include a list of individuals to which an employee is willing to speak; if a caller has not logged in an ID code identifying him as one of the people on the list, system 10 informs the caller that the employee being called is not available, thus screening incoming calls. Also customers can be provided with ID codes, to permit them to be considered during screening or to quickly leave messages that they called without leaving voice messages. Whenever the indentity of a caller is known, the individual being called is informed of this as system 10 searches for him prior to connecting the incoming call to him, to permit the individual being called to screen his own calls.

The ID codes for employees can be based on their names, and callers can merely be told to spell out the name of the individual being called.

A call can be placed to one of a group of individuals, e.g., those associated with customer complaints, personnel, etc., and apparatus 10 first selects one individual of the group and searches for him. If unsuccessful if locating this individual, apparatus 10 attempts to locate another individual in the group, and so on. The individuals can be assigned ranks, and when an individual receives a phone call, his rank can be changed to the lowest rank, so that system 10 searches for other individuals before connecting another group call to him.

In addition to identifying an individual or a group of individuals, system 10 can be programmed to ask the caller a plurality of questions enabling it to determine which employee the incoming call should be connected to, and can summarize the responses and provide them to the employee immediately prior to connecting the incoming call. For example, system 10 could be connected to a port 26 assigned a special service-related direct-dial number, and could ask callers to provide touch tone codes identifying the product involved, the nature of the problem (e.g, whether a television is providing a picture, sound, distortion, etc.),

the customer, and the location of the customer, and then either connect the incoming call to the appropriate employee or provide instructions. Also, in assessing the problem, system 10 could run through a diagnostic routine for the product, possibly providing instructions for adjustments that could be made by the caller. Also, the caller can enter an escape code connecting him with a human operator at any time.

The invention can also be used with other types of private telephone systems in addition to private branch exchanges (e.g., Centrex), and can be incorporated in a private telephone system.

CLAIMS

1. Apparatus for automatically processing telephone calls to a plurality of individuals accessible through a plurality of phone extension stations and/or outside telephone number stations, said apparatus comprising

phone connection means for automatically answering a call of a caller and for receiving individual identity information signals identifying an individual being called and for communicating with said plurality of phone extension stations and outside telephone number stations,

memory means for storing call handling information, said call handling information including information identifying, for each individual, at least one designated said phone extension station or outside telephone number station at which each said individual is likely to be present, said call handling information for at least some said individuals being different for different time periods, and

control means for automatically receiving said individual identity information signals and connecting said call to a station at which said individual is accessible,

said control means comprising

means for keeping track of time,

means for obtaining from said memory means said call handling information for said individual being called for the current time period, and

first means for causing said call to be connected to a said designated station.

2. The apparatus of claim 1 wherein said call handling information for at least some said individuals includes a plurality of designated stations at which said individuals are likely to be present, wherein said control means further comprises means for searching for a said individual by polling said designated stations and receiving individual access information from said designated stations, said individual access information indicating whether said individual being called is accessible at a said designated station, and wherein said first means for causing includes means for causing said call to be connected to a given station if said individual access information indicates that said individual is accessible at said given station.

3. The apparatus of claim 2 wherein said call handling information includes ranks for said designated stations, and said control means comprises means for sequentially polling said designated stations, beginning with the one with the highest rank and not polling lower ranked stations if said individual access information indicates that said individual is accessible at a given said station.

4. The apparatus of claim 1 wherein said individual identity information includes identities of at least one group of individuals being called, and said control means comprises

means for selecting one individual of said group, and

means for polling said at least one designated station and receiving individual access information from said designated station, said individual access information indicating whether said one individual is present at said designated station, and

second means for causing said means for obtaining, said means for polling, said first means for causing and said means for selecting to obtain call handling information for said one individual, to receive individual access information for said one individual, and, if said one individual is accessible at a given designated station for said one individual, to cause said call to be connected to said given station, and if said one individual is not accessible at any said designated station for said one individual, to select another said individual of said group to be said one individual and to obtain, receive and cause as specified above for said another individual, and to repeat this for all said individuals in said group until there has been an indication in said individual access information that a said individual of said group is accessible or until all designated stations for all said individuals of said group have been tried.

5. The apparatus of claim 4 wherein said indentify information for said group of individuals includes ranks for said individuals within said group, and said means for selecting comprises means for selecting the individual with the highest rank first and thereafter selecting individuals with lower ranks.

6. The apparatus of claim 5 wherein said memory means comprises means for identifying the last individual of a said group of individuals that has received an incoming call, and assigning that individual the lowest rank.

7. The apparatus of claim 3 wherein said individual identity information includes identities of at least one group of individuals being called, and said control means comprises

means for selecting one individual of said group, and

second means for causing said means for obtaining, said means for searching, said first means for causing and said means for selecting to obtain call handling information for said one individual, to search for said one individual, and, if said one individual is accessible at a given designated station for said one individual, to cause said call to be connected to said given station, and if said one individual is not accessible at any said designated station for said one individual, to select another said individual of said group to be said one

individual and to obtain, search, and cause as specified above for said another individual, and to repeat this for all said individuals in said group until there has been an indication that a said individual of said group is accessible or until all designated stations for all said individuals of said group have been tried.

8. The apparatus of claim 1 or 2 wherein said control means comprises means for responding to an escape code signal provided by said caller and for thereafter receiving signals causing it to modify call handling information stored in said memory means.

9. The apparatus of claim 1 wherein said phone connection means, said memory means and said control means further comprise means for asking said caller if said caller wishes to leave a message and means for receiving said caller's reply and for recording a message provided by said caller.

10. The apparatus of claim 2 wherein said phone connection means, said memory means and said control means further comprise means for asking said caller if said caller wishes to leave a message and means for receiving said caller's reply and for recording a message provided by said caller, and said control means further comprises means for delivering said message to said individual by causing said means for obtaining and said means for searching to search for said individual, and, if said individual access information indicates that said individual is accessible at a given designated station and wishes to receive said message, causing said means for receiving and recording to play back said message to said individual at said given station.

11. The apparatus of claim 9 wherein said control means further comprises means for responding to an escape code signal provided by said caller and for thereafter receiving and responding to message delivery signals provided by said caller causing it to play back said message to said caller.

12. The apparatus of claim 10 wherein said control means further comprises means for responding to a command provided by said caller to deliver said message to an alternate individual, and further comprising means to deliver said message to said alternate individual by causing said means for obtaining and said means for searching to search for said alternate individual, and, if said individual access information for said alternate individual indicates that said alternate individual is accessible at a given designated station and wishes to receive said message, causing said means for receiving and recording to play back said message to said alternate individual at said given station.

13. The apparatus of claim 1 or claim 9 wherein said control means further comprises means for receiving individual unavailability signals from said designated stations, and said control means further comprises means for providing said caller with an indication that said individual being called is unavailable.

14. The appratus of claim 2 wherein said call handling information includes information identifying an alternate individual for taking calls for said individual being called, and wherein said control means includes means for asking whether said caller wishes to speak with said alternate individual and for receiving a response from said caller, and third means for causing said means for obtaining, said means for searching and said first means for causing to obtain from said memory means said call handling information for said alternate individual and to search for said alternate individual at said designated stations and receive individual access information from said designated stations indicating whether said alternate individual is accessible at a said designated station, and, if said individual access information indicates that said alternate individual is accessible at a given said station, to cause said incoming call to be connected to said given station.

15. The apparatus of claim 1 wherein said control means includes means for asking questions directed to identifying the subject matter related to the call, receiving signals representing responses to the questions and referring to information in said memory means indentifying the proper individual for said subject matter, said proper individual being classified as the individual being called, said signals representing responses being said individual identity information signals.

16. The apparatus of claim 15 wherein said questions and said responses identify a specific product.

17. The apparatus of claim 9 wherein said phone connection means further comprises means for converting analog voice signals into digitized voice signals provided to said memory means, and means for converting digitized voice signals provided by said memory means into analog voice signals.

18. The apparatus of any one of claims 1 - 9 wherein said memory means includes stored digitized voice message signals, and said phone connection means includes means for converting said digitized voice message signals into analog voice signals.

19. The apparatus of any one of claims 1 - 18 wherein said phone connection means further comprises means for converting dual-tone multi-frequency signals into digital signals provided to said control means and to said memory means and means for converting digital signals provided by said control means and said memory means into dual-tone multi-frequency signals.

20. The apparatus of any one of claims 1 - 19 wherein said phone connection means includes means to detect call progress tones.

21. The apparatus of any one of claims 1 - 20 wherein said phone connection means includes means to provide signals simulating picking up a telephone.

22. The apparatus of any one of claims 1 - 21 wherein said phone connection means includes means to detect a ringing signal.

23. The apparatus of any one of claims 1 - 22 wherein said phone connection means includes means for interfacing with a private telephone system through one or more points of said private telephone system.

24. The apparatus of claim 23 wherein said means for interfacing includes means for providing signals to

a said port to place said incoming call on hold and to take said incoming call off of hold, and means for providing signals to connect said incoming call to another port of said private telephone system.

25. The apparatus of claim 23 wherein said means for interfacing includes means for interfacing with a plurality of ports through a parallel bus to said ports connected to an input/output controller connected to said control means.

26. The apparatus of claim 25 wherein said memory means includes stored digitized voice message signals, and said phone connection means includes means for converting said digitized voice message signals into analog voice signals.

27. The apparatus of claim 26 wherein said control means includes means for causing said input/output controller to obtain said digitized voice message signals from said memory means and to provide them to said phone connection means one byte at a time.

28. The apparatus of claim 27 wherein said phone connection means includes registers connected to receive said digitized voice message signals one byte at a time and to provide them bit serially to said means for converting digitized voice message signals into analog voice signals.

29. The apparatus of claim 25 wherein said phone connection means further comprises means for converting dual-tone multi-frequency signals into digital signals provided to said control means and to said memory means and means for converting digital signals provided by said control means and said memory means into dual-tone multi-frequency signals.

30. Apparatus for automatically processing telephone calls to a plurality of individuals accessible through a plurality of phone extension stations and outside telephone number stations, said apparatus comprising

phone connection means for automatically answering a call of a caller and for receiving individual identity information signals identifying an individual being called and for communicating with said plurality of phone extension stations and outside telephone number stations,

memory means for storing call handling information, said call handling information including information identifying, for each individual, at least one designated said phone extension or outside telephone number station at which each said individual is likely to be present, said call handling information for some said individuals including a plurality of said designated stations, and

control means for automatically receiving said individual identity information signals, searching for said individual and connecting said call to a station at which said individual is accessible,

said control means comprising

means for obtaining from said memory means said call handling information for said individual being called,

means for searching for a said individual by polling said designated stations and receiving individual access information from said designated stations, said individual access information indicating whether said individual being called is accessible at a said designated station, and

first means for causing said call to be connected to a said designated station if said individual access information indicates that said individual is accessible at said given station.

31. Apparatus for automatically processing telephone calls to a plurality of individuals accessible through a plurality of phone extension stations and or outside telephone number stations, said apparatus comprising

phone connection means for automatically answering a call of a caller and for receiving individual identity information signals identifying a group of individuals being called and for communicating with said plurality of phone extension stations and outside telephone number stations,

memory means for storing call handling information, said call handling information including information identifying, for each individual, at least one designated said phone extension station or outside telephone number station at which each said individual is likely to be present, and

control means for automatically receiving said individual identity information signals and connecting said call to a station at which a said individual is accessible,

said control means comprising

means for keeping track of time,

means for selecting one individual of said group,

means for obtaining from said memory means said call handling information for said one individual,

first means for causing said call to be connected to a said designated station,

means for polling said at least one designated station and receiving individual access information from said designated station, said individual access information indicating whether said one individual is present at said designated station, and

second means for causing said means for polling, said first means for causing and said means for selecting to obtain call handling information for said one individual, to receive individual access information for said one individual, and, if said one individual is accessible at a given designated station for said one individual, to cause said call to be connected to said given station, and if said one individual is not accessible at any said designated station for said one individual, to select another said individual of said group to be said one individual and to obtain, receive and cause as specified above for said another individual, and to repeat this for all said individuals in said group until there has been an indication in said individual access information that a said individual of said group is accessible or until all designated

stations for all said individuals of said group have been tried.

33. Apparatus for automatically processing telephone calls to a plurality of individuals accessible through a plurality of phone extension stations and/or outside telephone stations substantially as herein described with reference to Figures 1 - 8 of the drawings.

34. The apparatus of claim 1 wherein said phone connection means, said memory means and said control means further comprise means for asking said caller if said caller wishes to leave a message and means for receiving said caller's reply and for recording a message provided by said caller, and said control means further comprises means for delivering said message to said individual by causing said means for obtaining and said means for causing to connect to a said designated extension and receive individual access information, and, if said individual access information indicates that said individual is accessible at a given designated station and wishes to receive said message, causing said means for receiving and recording to play back said message to said individual at said given station.

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